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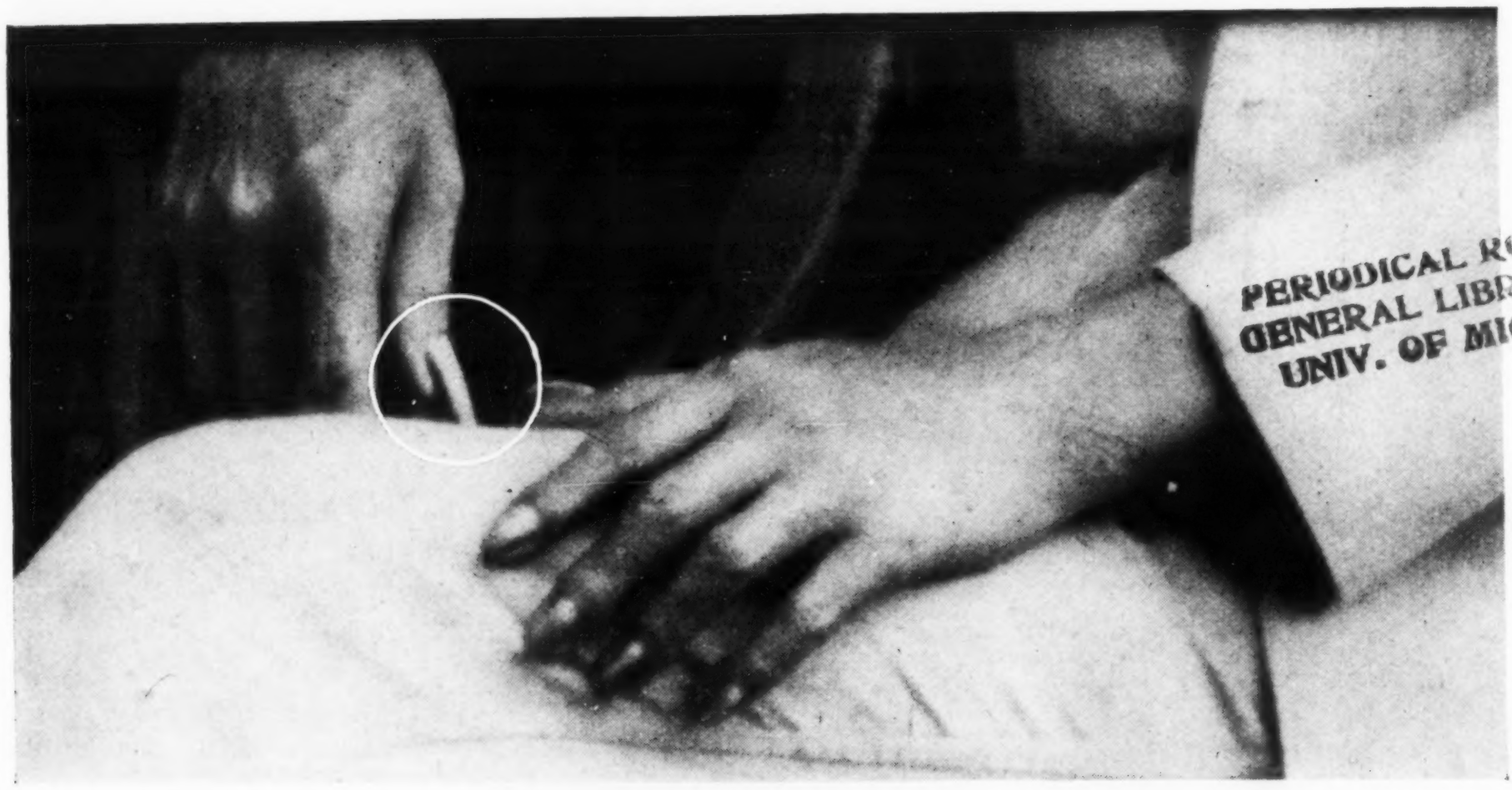
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CLAW-FINGERS — CARRIED BY THE GENES

Inheritance of Left-Handedness

Sorghum-Tassel Maize

The Mangosteen in America

A Featherless Fowl

Pigment Inheritance in Fish

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VOLUME 19 DECEMBER, 1928 NUMBER 12

The American Genetic Association

An incorporated organization devoted to promoting a knowledge of the laws of heredity and their application to the improvement of plants, animals, and human racial stocks

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The

Journal of Heredity

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COMING

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An Appreciation

A glimpse into a wide and varied experience of life which produced a remarkable philosophy.

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A new light on the genetics of secondary sex-characters.

Ectogenesis in Plants

Raising hybrid embryos outside the seed has interesting possibilities.

Twins

Five articles in prospect—new light on the heredity-environment tangle through identicals reared apart.

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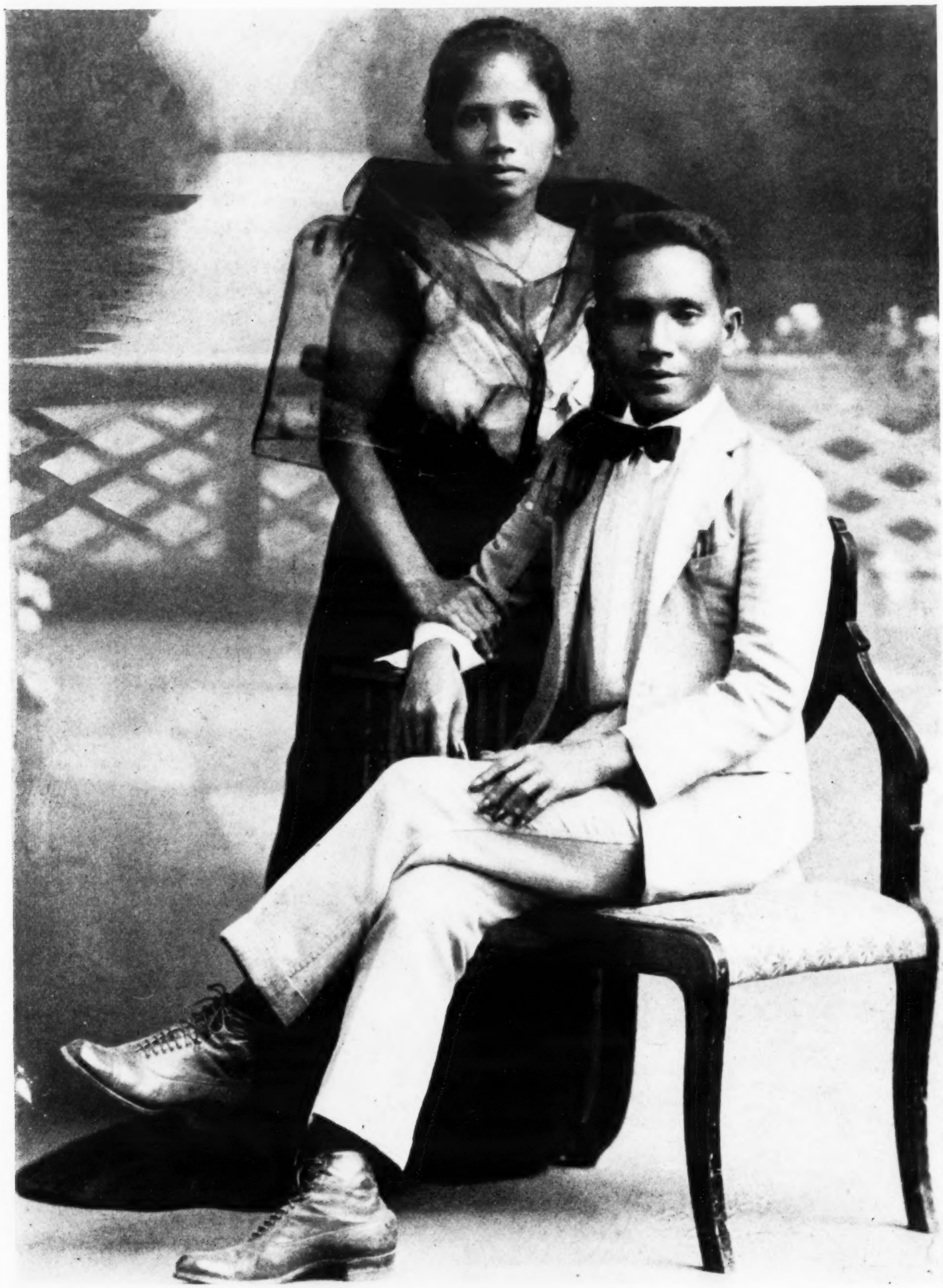


THE FIRST CLAW-FINGER

Frontispiece

The founder of the abnormal nail line and his normal wife. They have nine children, of whom five have claw-fingers and four are normal. None of the relatives of this man had the peculiarity, and the most likely assumption is that it arose by mutation.

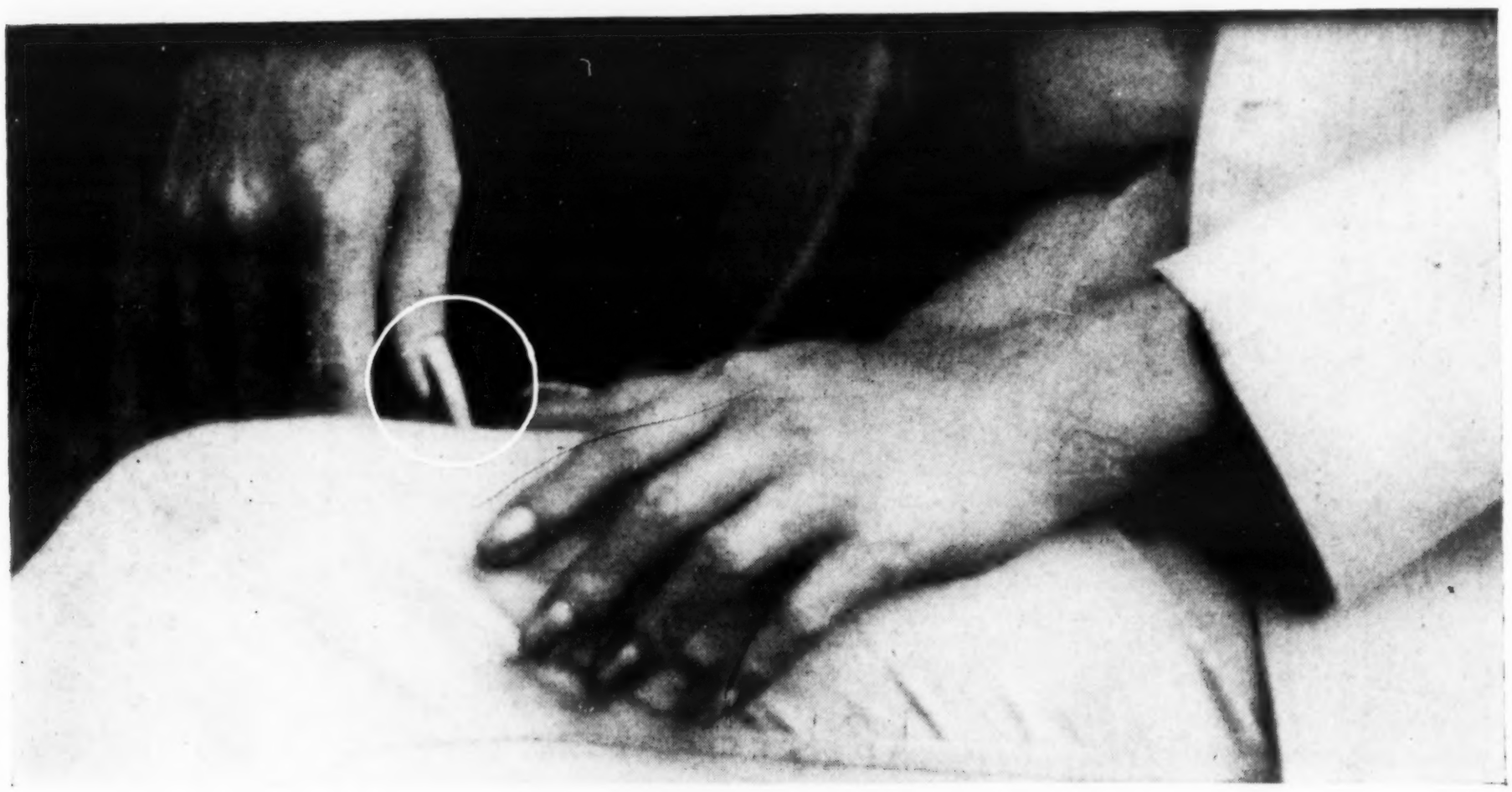
nine children,
this man had

A CLAW-FINGERED FAMILY

The Inheritance of a Nail Mutation in Man

LEOPOLDO S. CLEMENTE

Department of Zoology, College of Liberal Arts, University of the Philippines, Manila



CLAW-LIKE FINGERNAILS

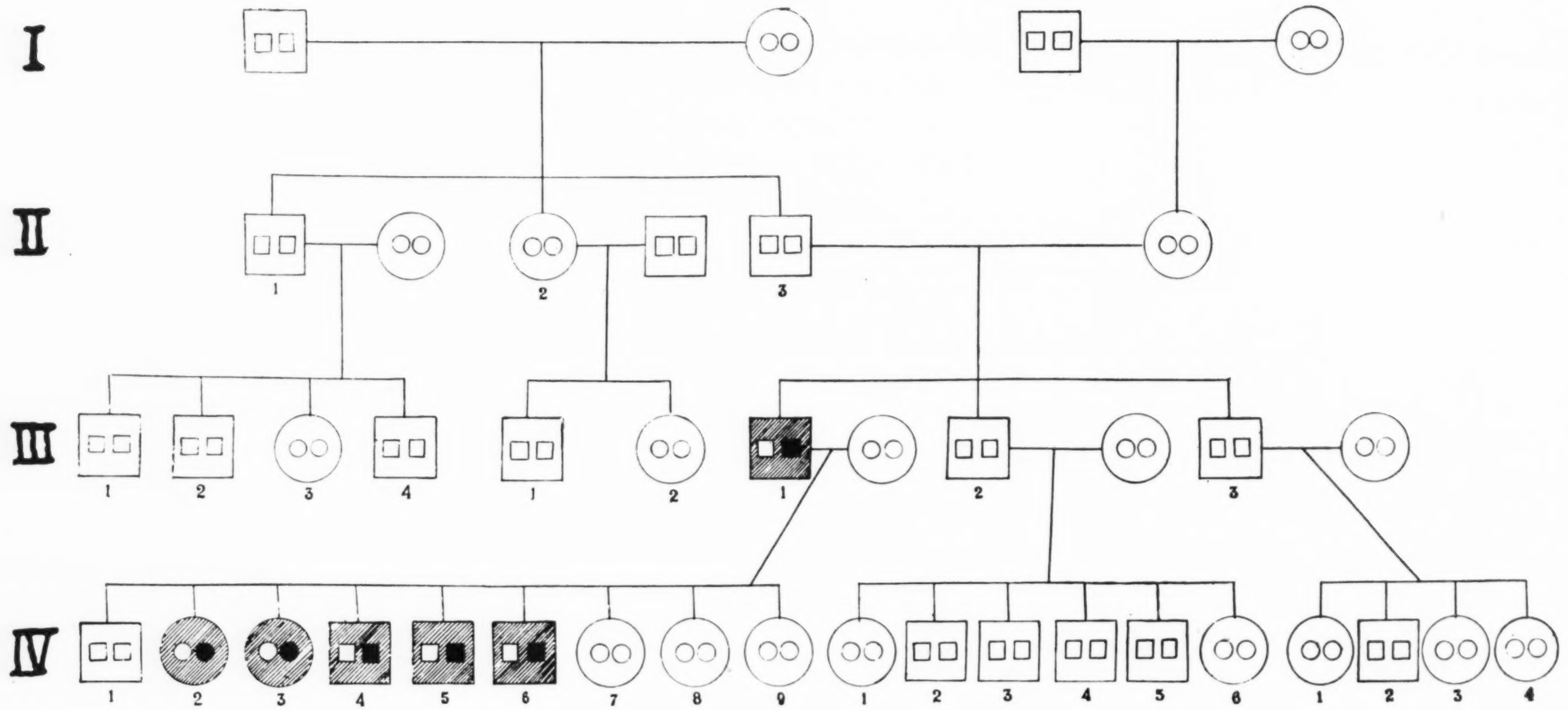
Figure 1

A magnified photograph of the hand of the man at left, to show clearly the abnormal nails. The nails of both feet are similarly affected. They have to be worn long because of the pain caused by shorter trimming.

THERE are already numerous known cases of deformities in man which affect the hands and feet, show dominance to normal condition in inheritance, and whose origin is by mutation. Among these may be mentioned polydactylism, a condition in which more than the usual number of fingers is present[10]; brachydactylism or the shortening of fingers and toes[5]; achondroplasia or abnormal shortening of the limbs[12]; brachymegalodactylism or shortening of the thumbs[1,7]; symphalangism or a fusion of the phalanges of the finger[14,6,9]; and syndactylism or a union of two or more digits.[11,3,8,13,15,2]

To the above list may be added a newly discovered case of abnormal thickening of the nail among a certain Filipino family which is also dominant to normal, and affects not only the nails of both hands, but also those of both feet. This nail abnormality seems to be a new case, for no literature on the subject has been found. Even Davenport[4] in his long list of heritable family traits failed to mention anything of this nature. This abnormality is known in Tagalog* by the name of "Kukong-Manok" on account of its resemblance to the claws of chicken. It is suggested in this paper that this phenomenon be given the name of "crassunguiculism," which is derived from the two Latin words "crassus," which means thick, and "unguiculus," which means nail. It is the purpose of this paper to present a short discussion on this very remarkable and apparently

*Tagalog is a native dialect in the Philippines.



Legend

- = Normal Male
- = Abnormal Male
- = Normal Female
- = Abnormal Female

PEDIGREE CHART OF THE CLAW-FINGERED FAMILY

Figure 2

The first affected individual, No. 1 (abnormal), row III, married a normal woman, giving nine children (1-9), row IV, of whom five (2, 3, 4, 5, 6) are affected and four (1, 7, 8, 9) are normal.

The second brother (No. 2 normal), row III, married a normal woman, giving six children (1-6), row IV, all of whom are normal.

The third brother (No. 3 normal), row III, married a normal woman, giving four children (1-4), row IV, all of whom are normal.

The immediate relatives of the first affected individual such as his parents, uncles, aunts, cousins, and grand-parents are all normal.

new heritable variation in the human nail.

The author is indebted to Mr. J. de la Rosa in furnishing the lineage of the family; to Mr. J. Fontañoza in taking photographs for the Frontispiece and Figure 4; to Mr. V. de la Rosa in making the sketch for Figure 3, and to Dr. A. T. Feliciano in making the diagram for Figure 2.

Historical

The case under consideration in this paper is that of a married man about forty years old, who is still living at the time of writing and whose brothers (no sisters), parents, grandparents, and near-relatives, as far as could be traced, were found to be free from the nail abnormality. Attempts were also made to trace the ancestry farther back than the grandparents, but it revealed nothing of the anomaly. Figure 2, where circles represent females and squares males, shows the family of the founder of the abnormal nail line as far back as his grandmother and grandfather on both his father's and mother's sides, and as is to be noted, not one of them shows the nail abnormality. Likewise, his uncles, aunts, and cousins are also shown to be free from the said anomaly.

How this individual, the founder of the abnormal nail line, came into possession of this new trait, considering the fact that it is absent in all his relatives, is certainly very problematical. It is said that the mother of the first afflicted individual ate plenty of corm of "apulid,"* at the time of conceiving him, and this was given as the cause of the origin of the nail abnormality. This explanation would be a case of inheritance due to maternal impression, a belief which is generally accepted by many, but which science could not accept as true, due to lack of experimental proof.

A very plausible explanation to account for such a sudden occurrence of the new trait would be by mutation similar to the origin of other hand and foot abnormalities. This nail abnormality, as will be seen later, is apparently dominant to normal nail, and this fact alone is enough to support the mutation view as to its origin, for had it been present in any member of his immediate relatives before, it would have manifested itself in the individuals affected, even in the heterozygous condition.

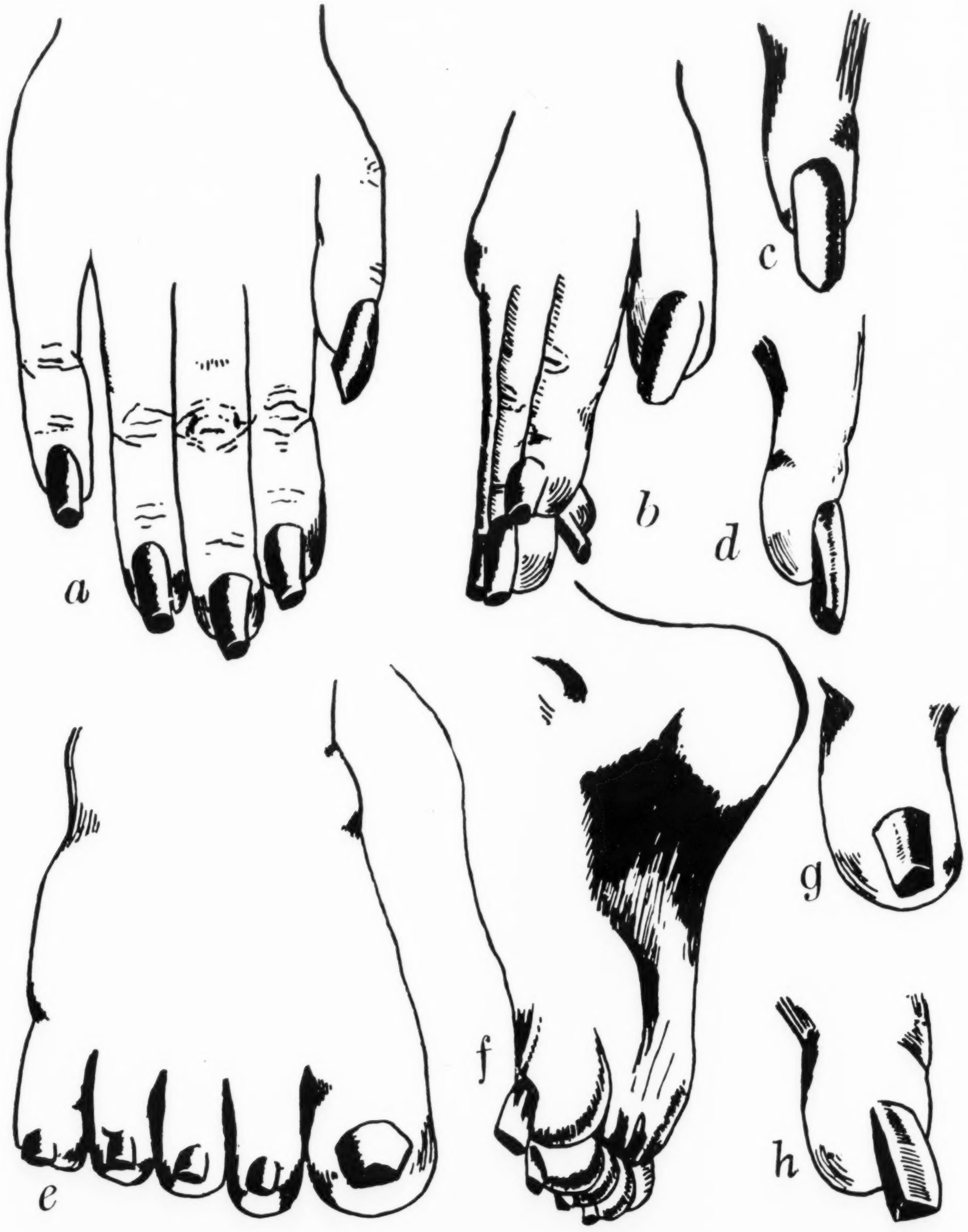
Description

The nails of the fingers and toes of the affected individuals are very much thickened and assume almost a cylindrical form as they leave the tip of the fingers. The thickening is partly due to an excessive growth of connective tissue of exactly the same material as the rest of the nail and partly due to the tendency of the nails to roll, thus giving them a rounded solid appearance very similar to a claw. If a cross-section of both normal and abnormal nails were to be made, the normal nail would appear as a simple arch, while the abnormal one would be somewhat rounded and solid. Whether or not the internal parts, such as the bones of the tip of the phalanges are also affected, can not be definitely settled at present, for no X-ray pictures of them are yet obtained. As far as could be determined, only the nails are affected, and this is assumed to be the case, inasmuch as there is no direct connection between the nails and the bones of the terminal phalanges.

Drawings *a* to *h* in Figure 3 show the dorsal and lateral views of the right hand and its thumb, and similar views of the right foot and its thumb of the fourth child, a male, possessing the abnormality. Figure 1 shows one hand of the father, while Figure 5 shows that of the fifth child, a male. Every one of the affected individuals

The immediate relatives of the [illegible] cousins, and grand-parents are all normal.

*"Apulid" is a Tagalog name given to the plant *Eleocharis dulcis* (Trin.), which belongs to the family Cyperaceae. It grows in abundance in the rice paddies in the Philippines after the rice crop is harvested and is considered a weed. The rootstock or corm assumes a rounded form and is very starchy and when cooked serves as a good food.



FINGERS AND TOES AFFECTED

Figure 3

Figures a-d show the dorsal and lateral views of the right hand and its thumb, while figures e-h show similar views of the right foot and its thumb, of the fourth child, a male, possessing the nail abnormality.

has exactly the same kind of nails in both hands and feet, as indicated in these figures. In the newly born baby, however, the abnormality is not so very well marked as in the older children.

This abnormality seems to have been not only a social hindrance to its possessor, for it is ugly to look at, but in addition, it has morphological as well as physiological disadvantages. The affected individuals can not walk normally with erect body and straight legs, especially when wearing shoes. In walking, the legs are tilted and somewhat dragged in an effort to escape bearing the weight of the body on the toes, for it hurts whenever a full pressure is put to bear upon them. This is more noticeable in running; the feet seemed to be placed flat on the ground and there is an absence of the rhythm and elastic movement that is exhibited by a runner with normal feet. In walking or running, the feet are raised without tipping the toes, for the thickness of the nails does not seem to allow such action, otherwise great pain is produced. Shoes that are roomy at the tip are the ones appropriate for wearing.

In cutting the nails, the toes and fingers are soaked in warm water for about an hour or so until they soften before successful operation could be done. If there is no previous soaking done, cutting the nails becomes difficult and causes a great deal of pain. The nails are always kept long, for close cutting is painful, if not impossible.

Inheritance

The first affected individual, the founder of the abnormal nail line, is the oldest and the only one among the three brothers who carries the abnormality. Every one of them were married to normal women, and only the affected brother gave two kinds of offspring with regard to the nail—normal and abnormal; while the other two brothers gave nothing but normal. This conclusively proves that this nail abnormality is hereditary.

Figure 2 is a chart showing these relations. The affected individuals are indicated by shaded squares in the case of males and shaded circles in the case of females. Unshaded ones are free from the abnormality. As is to be noted, only one of the germ cells of the affected individuals is shaded, for they are heterozygous or impure, as will be explained later.

The oldest brother (No. 1, Row III of Figure 2), the first affected individual, has at present nine children, all living at the time of writing. Four of these are boys and five are girls. (Figure 4). Among the boys, three are affected (Nos. 4. 5, 6) and only one is free from the abnormality (No. 1); while among the girls, two are affected (Nos. 2, 3) and three normal (Nos. 7, 8, 9). The number of children affected out of a total of nine is five, while four are free, or a proportion of about 1 to 1.

The second brother (No. 2, Row III of Figure 2) has at present six children, four girls and two boys. Every one of the children in this family is normal with respect to the nails.

The youngest brother (No. 3, Row II of Figure 2) has four children, one boy and three girls. All of them are also free from the nail abnormality.

Genetic Explanation

As has already been suggested previously, this nail abnormality came into existence through mutation, for no such case is known before among the relatives of the first individual affected. It is to be noted in this connection that no similar nail abnormality was ever seen or reported in the Philippines, at least, and this helps to substantiate its origin by mutation. If the mutation view is correct, the first abnormal individual is expected to have only one of his germ cells affected, for the chances that similar mutation could have taken place simultaneously in both germ cells is extremely improbable. It is to be expected, therefore, that the first individual affected is supposed to

THE CLAW-FINGERED FAMILY

Figure 4

This figure shows all the children except the oldest, of the founder of the abnormal nail line by a normal woman.

No. 1—Male—Normal (Not in the picture)
No. 2—Female—Abnormal
No. 3—Female—Abnormal
No. 4—Male—Abnormal
No. 5—Male—Abnormal
No. 6—Male—Abnormal
No. 7—Female—Normal
No. 8—Female—Normal
No. 9—Female—Normal

CLAW-FINGERS OF THE FIFTH CHILD

Figure 5

A magnified photograph of the hand of the fifth child, a male, to show clearly the nail abnormality. The nails of both feet are likewise affected.

be impure or heterozygous for the abnormality, and as such, he is expected to produce two kinds of offspring in equal numbers on marrying a normal woman. This condition is satisfied, for out of his nine children, five are abnormal and four normal, or a ratio of 1 to 1.

Where this nail mutation must have taken place first is still unknown. It is very likely that it has its first origin in the germ cells of either one of the parents, for its was among their offspring that it first appeared. It could not have taken place in the grandparents, for being dominant, it could not escape a generation without being manifested.

All the affected children as here indicated, are of the same genetic constitution with regards to abnormal nail, all being heterozygous. The normai children are likewise of the same genotype, all being homozygous for normal nail and hence are non-carriers of the abnormality.

This mutation seems to be autosomal and dominant rather than a sex-linked, and is thus similar to all hand and foot abnormalities heretofore described. If it were a dominant sex-linked mutation, only the female offspring of the first affected heterozygous male by a normal female should be affected, but instead both males and females show the abnormality in approximately equal ratio. Of the total five affected, two are females and three are males.

The Future of the Offspring of the Affected Father and Those of Later Generations

There are two types of children of the affected father, namely, normal and abnormal as regards the nails. The probability is that they will marry normal individuals, for no such trait is found outside of the family. If such

would be the case, the abnormal children, all being heterozygous, would give again normal and abnormal children in equal frequency like the father. The normal ones, on the other hand, should be the case, the abnormal children and would be expected to be absolutely free from the abnormality, even though they came from the affected stock.

If in the course of time this strain should multiply so that in later generations marriage between the affected individuals might take place, then we could expect the following possibilities:

(1) If two heterozygous individuals get married, such could be expected to give a typical simple mendelian ratio of 3 abnormal to 1 normal.

(2) If two affected individuals should intermarry, one of which is homozygous and the other heterozygous, such mating should give nothing but abnormal, of which half is pure (homozygous) and the other half impure (heterozygous).

(3) If two abnormal homozygous individuals should intermarry, all their offspring are expected to be pure for the abnormality. What the appearance of a homozygous individual would be could not be definitely told, but it is likely that it would look like the heterozygous form, inasmuch as there is complete dominance of this character over normal.

Conclusions

1. This nail abnormality came into existence through mutation, for it was not found among the ancestors of the first affected individual.

2. It is a single-factor mutation which affects only the nails of both hands and feet and is allelomorphic to normal nail. It behaves as a simple Mendelian dominant character.

3. It is an autosomal and not a sex-linked mutation, for both the sons and daughters of the first affected heterozygous individual show the defect.

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THE MANGOSTEEN IN AMERICA

WILSON POPENOE
Director of Agricultural Experiments, United Fruit Company

THIRTEEN years ago, Dr. David Fairchild brought together a fund of information regarding the behavior of the mangosteen in the Asiatic tropics,* and pointed out some of the problems which remained to be solved in our own part of the world. Summing up the matter, he wrote:

> It is perfectly safe to say that there is no obstacle to the dissemination of this queen of tropical fruits throughout the warmest parts of the American continent; and that if it can be grown on a commercial scale within easy shipping distance of United States markets, the connoisseurs of this country will have added to their menu a fruit which has been long acknowledged by many as the most delicately flavored in the world.

The earliest recorded introduction of the mangosteen in tropical America took place, so far as I have been able to ascertain, in Trinidad. The credit for having sent plants to Port-of-Spain probably belongs to that venerable mother of tropical horticulture, Kew Gardens.

During a large part of the last century, the authorities at Kew were tireless in their efforts to transplant valuable products from one part of the tropical world to another. The method usually employed was to send seeds or other propagating material to England, thus avoiding the direct voyage, dangerously long for seeds and plants in those days, between the tropical colonies of Asia and those of America. Sturdy young specimens, grown in the greenhouses at Kew, were later dispatched in wardian cases to the botanic gardens which had been established in many widely-separated regions.

Date of Introduction Uncertain

The precise date at which the mangosteen was first planted in Trinidad is not known to me. A note written by J. H. Hart in the annual report of the botanic garden at Port-of-Spain for the year 1889 (which P. J. Wester has kindly called to my attention), states that "Although it first fruited as long ago as 1875 its periods of fruiting have always been (I learn from employees here) of a very intermittent character, sometimes two or three years elapsing between crops."

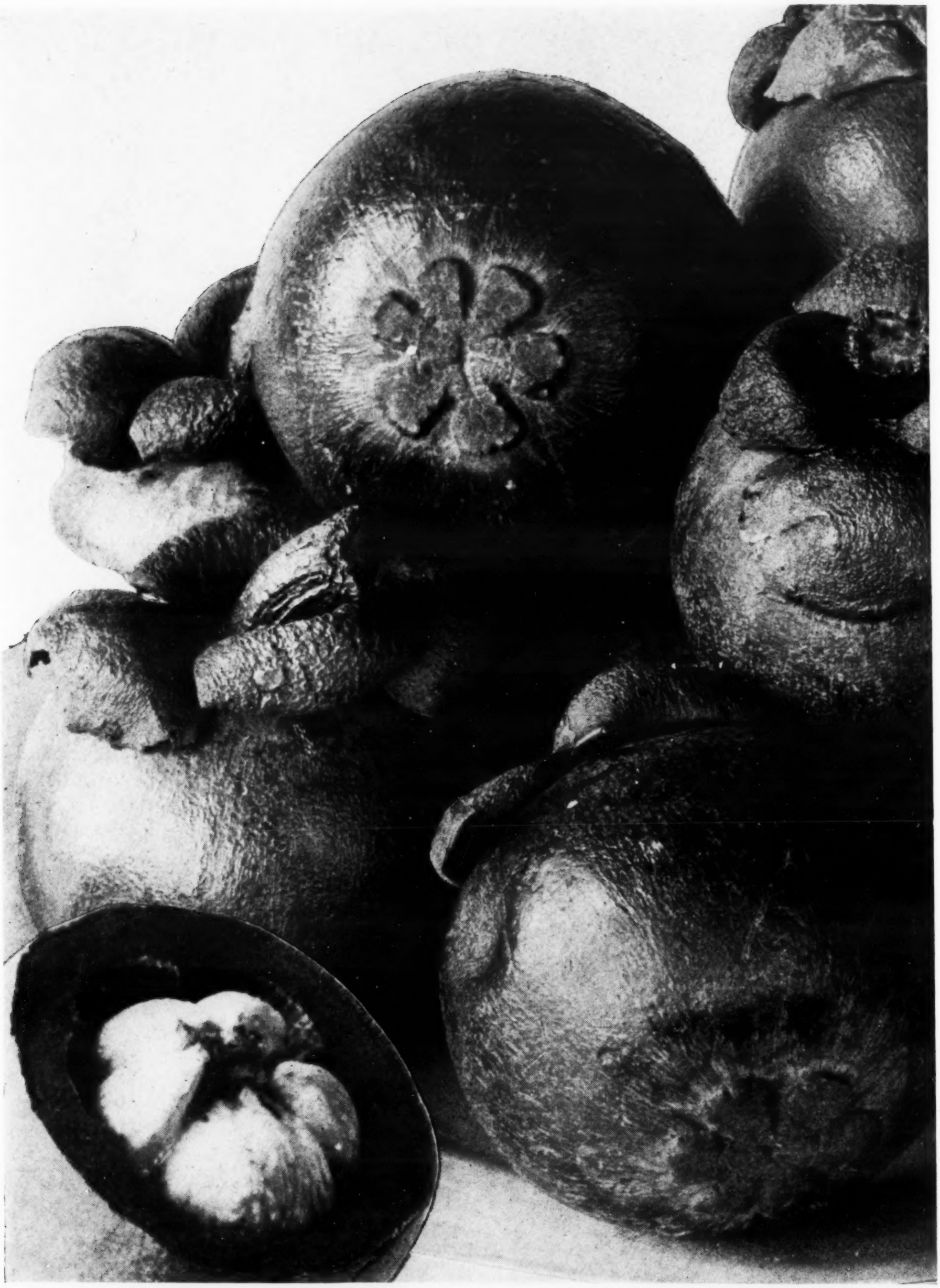
Since the tree requires eight or ten years to commence bearing, Mr. Hart's statement implies that the date of introduction could scarcely have been later than 1860. More probably it was before 1855.

In 1885 a tree came into bearing at Castleton Gardens, Jamaica, according to records which have been found by H. H. Cousins, now Director of Agriculture in the island. This was perhaps the second successful introduction in tropical America.

Doubtless the first fruiting of the mangosteen in this part of the world attracted much attention. It would be interesting to unearth comments among the notes of British horticulturists who were in the West Indies at the time. One can imagine, also, the pleasure with which the news was received at home by some of the old-school botanists like Sir Joseph Hooker,—devoted plantsmen who had become familiar with this fruit during their wanderings in the Asiatic tropics, and who were instrumental in sending it to the New World. Sir Joseph, it may be remarked, was responsible for its introduction into Dominica, where it was planted in 1886.

Strangely enough, Castleton is the only spot on the island of Jamaica

Journal of Heredity, Vol. VI, No. 8, Aug., 1915. Pp. 339-347.



THE QUEEN OF TROPICAL FRUITS

Figure 6

The mangosteen, a native of the Asiatic tropics, was introduced into the West Indies about half a century ago. Much difficulty has been experienced in extending its cultivation in this part of the world, but bearing trees are now to be seen in several of the West Indian islands, and on the mainland in Guatemala, Honduras, Panama, and Ecuador. The fruit is one which has long been famous for its handsome appearance and delicate flavor. Early voyagers to the East lavished much praise upon it, comparing it to nectar and ambrosia, and declaring it the most delicious fruit of the Indies.

where the tree has been grown successfully. Dr. Cousins* says:

> Although we have for the past 35 years distributed young plants to various parts of the island, I can find no record of any trees producing fruit. In most cases they fail to grow. The tree is susceptible to sea-breezes; it requires intense heat and a moist atmosphere.

Nearly a hundred specimens of various ages are now scattered about the hillsides at Castleton Gardens. The species is well established in Jamaica, therefore, even though the possibilities of extending its cultivation throughout the island appear to be limited. That the conditions at Castleton itself are none too favorable is evident from the fact, reported by Dr. Cousins, that trees grown there rarely bear fruit before they are twenty years old.

Jamaica, Trinidad, and Dominica are the three West Indian islands where most has been learned regarding the habits and requirements of the mangosteen. An inquiry addressed to W. G. Freeman, Director of Agriculture at Port-of-Spain, brought forth the statement that there are five trees at St. Clair Experiment Station about twenty years old, and two more in the Botanic Gardens. The ones at St. Clair, where the rainfall is about 65 inches per annum, bear uncertain crops, ranging from five to 100 fruits per tree annually. They are growing on sandy loam, and are shaded by large trees of Gliricidia and Saman. Mr. Freeman adds:

> The difficulty in mangosteen culture is the establishment of young plants. The seeds germinate, but the plants refuse to grow after they are 2 to 3 months old, and eventually die off. We have tried growing in pots and planting out with the same results.

At Monte Cristo estate, in the same island, there are two trees, now about 18 years old. Mr. Ernest Monceaux states that these began bearing at six or seven years of age, and that the 1924 crop was 1400 fruits. They are planted under high woods, in light shade, on a plateau with rather dry sandy loam soil. The annual rainfall is about 120 inches, and the trees receive no irrigation. "Both trees are very good bearers," writes Mr. Monceaux, "but crops cannot always be depended upon, as they fail sometimes one and sometimes two years, for unknown reasons." Fourteen additional young trees have been planted at Monte Cristo. These range from three to seven years of age.

Mr. F. G. Harcourt, curator of the Botanic Gardens, Dominica, has furnished the following excellent account, which covers the most extensive attempt at mangosteen production yet made in the American tropics:

> The Mangosteen was introduced into Dominica in the year 1886 by the Hon. Dr. Nicholls, C. M. G., who received a small plant from Sir Joseph Hooker, then Director of the Royal Botanic Gardens, Kew. This specimen was planted by Dr. Nicholls at the St. Aroment Estate. In the red upland soil the plant throve vigorously in this locality with an average annual rainfall of 105 inches.
>
> During the middle nineties of the last century it commenced to fruit annually, and as the tree increased in size, the crops increased in quantity. The tree has now attained a considerable size and is remarkably healthy.
>
> In the year 1892 a second plant of the Mangosteen was received from Kew. This was planted in the Botanic Gardens, in which place the soil is dark in color and of open texture through which the water passes very quickly. This, however, does not appear to be a suitable soil for the Mangosteen but owing to the great care which was lavished on the plant it has now developed into a fair specimen and bore fruit in the sixteenth year after planting. Another drawback to the Mangosteen in the Botanic Garden is, that the rainfall only averages 80 inches per annum and the amount of moisture therefore appears to be insufficient.
>
> In the middle and late nineties, the plant at St. Aroment fruited and seed was sent to the Botanic Gardens by Dr. Nicholls. A few plants were raised, a number of which were given to Mr. Justice Pemberton for trial at Point Mulatre, an estate situated on the Windward coast with an elevation of 300 feet. At about this time Mr. Julien Archer obtained a few seedling mangosteens from Trinidad for Mr. Justice Pemberton, and these brought the number of trees under trial at Point Mulatre up to twelve.

*In a letter dated 12th March, 1927.

Both the soil, which is a stiff red one with a covering of humus, and the rainfall which is at least 160 inches per year, proved highly suitable. The plants grew with vigor and in 1920 there were 12 bearing trees at Point Mulatre. At the present time the number is between 16 and 20 with others coming on. These, with the tree at the Botanic Gardens and the one at St. Aroment are the only fruiting trees in the island. So abundant was the crop at Point Mulatre last season that Mr. Justice Pemberton sent Mangosteens weekly to his friends in sacks.

In favorable situations the Mangosteen bears enormous crops during alternate years.

Enough has been accomplished to show that this tree will thrive at low elevations in the hot, humid valleys of Dominica with a rainfall of over 100 inches per annum and under such conditions the fruiting stage may be reached in ten or twelve years after planting.

Although there is no record in Dominica of the number of fruits per tree, the ones at Point Mulatre must be giving at least a thousand.

The quality of the fruit at Point Mulatre compared with those of the Botanic Gardens and St. Aroment is very striking; all the fruiting trees bear heavily, but at Point Mulatre where the atmospheric conditions are most suitable the fruit is much more luscious.

A considerable number of Mangosteen plants have been distributed in Dominica during the past few years, but, unfortunately, many of the persons who received the plants for trial have left the island; consequently, many of the plants were neglected and finally disappeared. It is pleasing to note, however, that in some of the districts (1,900 feet elevation) with rainfall at least 186 inches per annum, the Mangosteen is doing wonderfully well, and quite a number have already attained a height of 10 feet.

At the present time* there are in the nurseries of the Botanic Gardens some 1,500 healthy young plants raised from last year's seed, and in addition about 200 good plants established in bamboo pots. The latter are now two years old.

O. W. Barrett, Agricultural Director for the Island of Porto Rico, has sent me photographs of two bearing trees which are on the grounds of the U. S. Agricultural Experiment Station at Mayagüez. These trees were brought to Porto Rico from Trinidad and have been producing fruit for some years. So far as known, they are the only bearing specimens in the island. They are said to be growing on red clay, under an annual rainfall of 75 to 80 inches.

This completes the list of bearing trees in the West Indies, so far as I have been able to locate them. Possibly there are a few others in such islands as St. Vincent, St. Lucia, or Tobago; but no reports have come to hand.

Trees in Central America

Turning now to the mainland, the oldest specimen is probably that growing at Izabal, Guatemala, on the property which formerly belonged to Mrs. Lucie Potts. This tree was started at Castleton Gardens, Jamaica, about 1891, and was sent from there to Guatemala by James Deering of Chicago. Two years ago Mrs. Potts, now deceased, gave me the following notes:

This tree flowered, but dropped all its blossoms regularly. Finally, I took the carving knife and cut the bark diagonally as high as I could reach. The next year fruit was produced, and regularly thereafter until we moved to a banana plantation on the opposite side of Lake Izabal.

At the present time Mrs. Potts' tree is in good condition. It produced a large crop in 1925 (perhaps a thousand fruits or more) and no crop at all in 1926. There were a few fruits in 1927, and a fair crop was borne in 1928.

This tree stands upon the shore of the lake not more than forty feet from the water's edge. The surface soil is a fairly rich black loam, while the subsoil is gravel and sand with heavy clay beneath. A large mango tree stands close by, and somewhat crowds the mangosteen, which is now about 35 feet high, with a spread of 30 feet.

Less than one hundred miles from Izabal, as the crow flies, is a thirteen-year-old specimen at Agua Blanca Farm, not far from Tela, Honduras. As a small seedling this was sent from the Philippines by Governor Cameron Forbes. It produced its first fruits (only a very few) in 1925, when ten years of age. It failed to bear in 1926, and yielded nine fruits in 1927. The soil on which it is growing is a fine

*August 14, 1925.

MANGOSTEEN TREES IN ECUADOR

Figure 7

The trees were planted about 1905. This is the largest planting of mature mangosteen trees on the American continent.

sandy loam, containing relatively little humus. The annual rainfall of the region is approximately 60 to 80 inches.

Though several attempts were made to establish the mangosteen in the Canal Zone, all met with failure until 1921, when Messrs. Fairchild and Dorsett of the U. S. Department of Agriculture landed there with a number of plants from the greenhouses at Washington. Two years later, most of these came under the care of Holger Johansen, who was at that time starting the Plant Introduction Garden at Summit. One of these trees, thought to have been four years old at the time it was brought from Washington, came into bearing at Corozal in 1926.

Farther south on the mainland, near Guayaquil, Ecuador, there are about 15 trees which were called to my attention by Professor James Birch Rorer in 1920. These are on a cacao plantation belonging to the Madinyá family. Little is known of their early history, except that the founder of the plantation, now deceased, was a connoisseur of rare plants, and brought them with him, most likely from Jamaica, when returning from one of his periodic journeys to Europe. As far as could be ascertained, they were planted between 1900 and 1905. They had been in bearing some years when we examined them in 1920.

These trees are growing on fine sandy loam, close to a stream of considerable size, but fifteen or eighteen feet above the dry-season water level. The region is one of rather marked climatic contrasts. An extremely wet period is followed by a severe dry season of long duration. Little information is available regarding the cultural treatment which the trees have received. Neither are data at hand regarding the amount of fruit which has been produced. It is regrettable that so little should be known regarding this, the largest planting of mature mangosteen trees on the American continent.

No other bearing trees on the mainland are known to me, though I have made an effort, during my travels in tropical America, to learn of them. As to young plants, not yet old enough to commence fruiting, Mr. Johansen has established quite a number in the Canal Zone, and we are attempting to build up an orchard at Lancetilla Experiment Station, near Tela, Honduras. There are several specimens on properties of the United Fruit Company in Costa Rica. These were sent from Washington by the U. S. Department of Agriculture, about 1921. The largest is now 20 feet high, with a spread of 15 feet. It is growing in the Superintendent's garden at Zent.

Cultural Difficulties

Having reviewed the distribution of the mangosteen in America, so far as can be done from the data available, let us turn to a brief consideration of some of the cultural problems.

The first and most important, undoubtedly, is propagation. Seeds are difficult to transport long distances, and the great majority of shipments sent to America from the Eastern tropics have arrived in worthless condition. The well-known firm of Vilmorin, Andrieux et Cie, has been more successful in packing mangosteen seeds for shipment, however; several lots sent by this house to the U. S. Department of Agriculture, and to us at Tela, Honduras, have given rise to most of the young plants now growing on the American mainland.

During his travels in the Asiatic tropics, 1925-1926, Dr. David Fairchild was also successful in working out a method of packing which produced results much better than have usually been obtained in the past.

It is evident, therefore, that viable seeds can be obtained from the Orient; and in addition, limited quantities are now available,—somewhat irregularly, perhaps,—in various parts of the American tropics.

Young mangosteen plants are no-

THE LARGEST MANGOSTEEN TREE IN CONTINENTAL AMERICA

Figure 8

While still a small seedling, this tree was sent from Jamaica to Guatemala, where it was planted by Mrs. Lucie Potts at her home on the shore of Lake Izabal. It is now about 35 years old, and is the largest specimen to be seen in America, with the possible exception of some in the West Indies. Occasionally it produces a large crop of fruit; about two years out of three the crop is very small. Photo by N. A. Green, United Fruit Co.

toriously hard to raise. Many casualties usually occur between the time of germination and the end of the second year. The difficulty has been attributed to an inherently weak root system. To eliminate this, grafting on more vigorous species of Garcinia has been recommended. But so far as I am aware, no satisfactory stock-plant has been discovered.

Recently, P. J. Wester has recommended the Philippine bunag (*Garcinia benthami*) as worthy of trial. Successful unions have been obtained between this species and the mangosteen. We have at Tela, Honduras, a young tree grafted on *G. xanthochymus;* this was sent to us from the greenhouses of the U. S. Plant Introduction Garden, Bell, Maryland, where it was propagated by Edward Goucher. Though it has been in the open ground since 1925, the cion has made practically no growth. There seems to be a definite lack of congeniality between it and the stock.

After having investigated the subject in the Orient, Dr. Fairchild wrote me in 1926:

> If you were to ask me how to go ahead with the mangosteen I would say, go on as fast as you can with your seedling trees. Don't wait for stock plants on which to bud or graft. Don't even wait to be able to bud or graft the mangosteen successfully, for it seems to be a self-fertile, possibly (quite probably) parthenocarpic form and comes true from seed. Cramer and Ridley both told me they had never seen any varieties. There were thinner shelled and smaller fruited forms than the normal, but the impression which one gets of a mangosteen orchard is not at all the impression of the ordinary seedling fruit-tree collections of differing strains.

In the late summer of 1925, we planted at Tela a number of seeds from the old tree growing on the shore of Lake Izabal, Guatemala. Germination was prompt. The young seedlings were potted off, and carried for some months in pots. They came through the cool weather of the rainy season rather badly, and during the following summer their appearance was far from satisfactory. Many of the leaves turned brown gradually from the margins inwards, and not a few of the plants were finally lost.

We again planted seeds in 1926, and handled the young seedlings in the same fashion, but attempted to use a better type of potting soil. Results were satisfactory for a time, but after they had been in pots about six months the plants began to fail. In order to supply more uniform moisture conditions, we set them in nursery beds under the shade of a lath-house. Here they picked up gradually, and after a few months no further trouble was experienced.

In 1927, a new batch of seedlings was potted almost as soon as they had germinated. After being carried in 3-inch pots for three months only, they were set in nursery beds as with the former lot. These plants have given us few worries.

In transplanting seedlings from nursery beds to their permanent places in the orchard, during the summer of 1927, we observed that the root systems were formed deeply underground. From the surface down to a depth of three or four inches few fibrous roots were to be seen; below that, to eight or ten inches, they were abundant. Above ground, the plants stood six to twelve inches high. From the fact that roots are developed at lower levels than is the case with most other plants with which we are familiar, we have assumed the trouble may have been, when the plants were grown in pots, that they could not send down roots to the zone they normally would have occupied.

Reports from other regions state that seedlings started in the open ground have not succeeded better than those in pots. It has come to be generally believed that one must begin with a good many more seedlings than he expects ultimately to utilize, so as to allow for heavy losses during the first two years. However, Alfred F. Butler, horticulturist at Lancetilla Experiment Station, is convinced that

we are now prepared to handle mangosteens with no heavier mortality than would be expected with other types of nursery stock. Our experience in Tela may not hold good, of course, under different conditions of climate and soil.

It is noteworthy that the mangosteen (as pointed out by Dr. Fairchild in the letter quoted above) does not show the amount of variation, when grown from seed, which we are accustomed to expect in mangos, avocados, and other tropical fruits. The major argument in favor of grafting is therefore eliminated; and if the difficulty usually experienced in rearing seedlings can be overcome, no serious obstacle will remain to check the dissemination of this valuable tree in tropical America.

As to climate and soil, it is obvious from the successful results which have attended the planting of mangosteens in various regions, that the tree is not really exacting. If moisture is naturally lacking, it can be supplied by irrigation. Mr. Harcourt's report from Dominica indicates that the quality of the fruit may not be the same under all climatic conditions. The difference, however, will probably be no greater than with other trees such as the orange, which often produce better fruit in one region than in another, though growing satisfactorily in both.

When possible, it would seem desirable to plant on land which has abundant subsoil moisture. This is probably the secret of success in some of the instances where mangosteen trees are growing close beside streams or lakes. There is no doubt that the tree wants abundant moisture, but it also wants perfect drainage.

The cultural problems of mangosteen production do not seem to be as numerous, nor as difficult as they were believed to be twenty or thirty years ago. But when all others are solved, one will still remain for which no solution is yet in sight. Few tropical fruit trees are so slow to come into bearing, and few (judging from experience in tropical America) produce good crops with such irregularity. For these reasons, the mangosteen can scarcely hope to compete with the mango as a staple fruit to be consumed in quantity by all. More likely it will remain something of a luxury, to be eaten on occasions, and to fetch a high price whenever it appears upon the market.

But this, after all, cannot be considered an inappropriate fate for the Queen of Fruits. To make mangosteens as commonplace as mangos would dispel the glamor with which the very name has been surrounded. "Of all the fruits of the Indies, it is by far the most delicious" wrote one of the early voyagers. "And the rarest," let us add as an American postscript.

A CONSTITUTIONAL SCARCITY OF PLUMAGE

Figure 9

A presumably thoroughbred Rhode Island Red fowl with a white Leghorn graft on the rump. This bird, twenty-seven weeks old when photographed, had never had more complete plumage than this. The fact that the White Leghorn graft has grown normally indicates the defect is not due to an endocrine disturbance.

A CASE OF ALOPECIA IN THE FOWL

C. H. DANFORTH
Department of Anatomy, Stanford University

AMONG the mammals, cases of relative hairlessness are not infrequent.[1] Such cases fall in two general classes, those which are due to external or parasitic causes, such as the mange of dogs and foxes —alopecia in its classical sense—and those which are constitutional in origin. The latter are often clearly hereditary and are referred to by a variety of terms. However, it has become customary to designate all cases of abnormal deficiency in hair as *alopecia*, irrespective of the etiology. Since this word has thus been raised from a special to a very general connotation, it would seem justifiable to extend its application still further so as to include not only conditions in which hair follicles are unable to perform their function normally, but also those in which feather follicles are similarly handicapped. If such an expansion of the term be permitted, the subject of this sketch may be described as a victim of alopecia.

The specimen (Figures 9 and 10) is a Rhode Island Red fowl of the female sex, which was twenty-seven weeks old when the photographs were taken. Figure 11 shows another Rhode Island Red of the same age and general history. These two birds, along with several others, were purchased in December from a commercial hatchery as first quality day-old chicks. This particular hatchery rigidly discards inferior and abnormal specimens, so it is improbable that any deviation from normality was to be seen at that time. Furthermore, on their second day in the laboratory the skin of the saddle region was removed from each of the Rhode Island Reds and white Leghorn skin grafted in its place. In the course of this procedure nothing unusual attracted the attention of the operator. Consequently it may be assumed that the alopecia was not apparent during the first few days after hatching.

Many Rhode Island Reds normally pass through a period of partial nudity during which their feathers are not sufficiently developed to replace the down which has become too thin to cover the increased body area. This transient condition is followed by the development of an abundant plumage which in both sexes usually reaches an essentially adult form before the end of the sixth month. (Figure 11.)

The first record of anything unusual about the bird shown in Figures 9 and 10 was made when she was 54 days old. It was recorded at that time that she was unusually nude, even for a Rhode Island Red. The patch of white Leghorn skin on her back was producing an abundance of feathers, but this fact attracted no especial attention since it was known that White Leghorn skin at first develops feathers more rapidly than that of Rhode Island Reds, irrespective of whether it grows in its natural position or as a graft on some other breed.[2] In this particular case, however, the relative lack of feathers on the host skin was not made good in the usual way but became even more marked during the next few weeks.

For the past five months the condition of the plumage has been that indicated by the photographs. The head and upper neck have almost the normal number of feathers, but all other parts of the body show a decided deficiency, varying in degree in different regions. There is a fairly good tuft on the lower half of each leg, and some good sized feathers on the lower neck, breast and belly. What appears

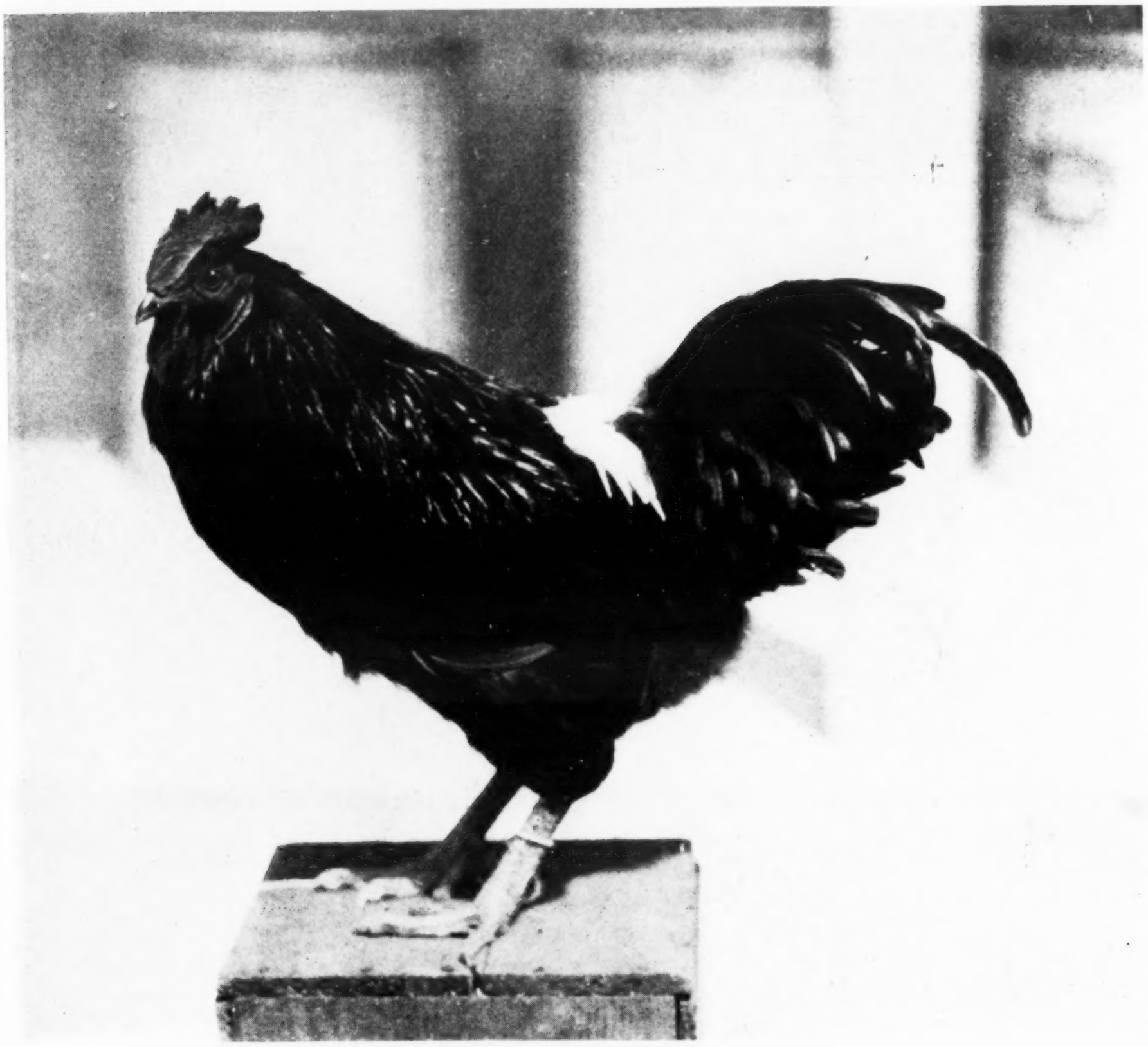
FEATHERS MOSTLY ON WINGS

Figure 10

Another view of the same bird shown in Figure 9, held so as to reveal more completely the extent of feather deficiency.

in Figure 9 to be a fair growth on the back, in reality consists largely of a tuft at each "elbow," as revealed in Figure 10. There has at no time been more than a few primaries and secondaries in the wings. The tail feathers have remained rudimentary. The contrast between this and a normal individual of the same breed and age is indicated by Figures 9 and 10.

In the areas of deficiency many of the follicles appear to be entirely inactive, while others produce broad (sometimes excessively large), soft,



NORMAL FEATHER DEVELOPMENT

Figure 11

A normal cockerel of the same age and hatch as the one shown in Figures 9 and 10. This bird also had a Leghorn graft on his back.

abnormal pin-feathers or short, stubby feathers whose barbs project from the follicles without apparent midshafts or quills. Pulling out such feathers or pin-feathers frequently elicits little or no manifestation of pain.

The exact cause of the deficiency is uncertain, but the condition parallels in many respects some of the constitutional alopecias that occur in man.[3] It also agrees with many human and other mammalian cases in being preceded by an apparently normal condition of the cutaneous appendages.

In some of the clinical cases that have been described the alopecia was associated with other abnormalities. In this instance nothing unusual was noticed except a slight retardation in development and a decidedly retiring, "non-social" disposition which persisted nearly till maturity. She began laying at a little over eight months of age, as contrasted with an age of not over six or seven months for control pullets. Whether the somewhat slower general development and abnormal reactions were in reality secondary to the alopecia (e. g., due to excessive

loss of heat), or whether the several phenomena were all due to a common cause can not be answered with certainty, but the former alternative seems the more probable.

It is a common practice to attribute sporadic cases of alopecia such as this to some form of endocrine disturbance. But in the present case some doubt is raised as to the correctness of such an interpretation by the fact that the grafted skin, which was subject to the same endocrine influences as that of the host[4] has continued to develop feathers in a normal manner. If it were to be assumed that the nakedness in this case was directly due to endocrine influences, it would be necessary to make the further assumption that feather follicles of the Rhode Island Red and those of the Leghorn have a differential susceptibility and that the grade of stimulus produced by the endocrines of this particular individual falls between the threshold of the former and that of the latter.

It would be simpler to assume that through some endocrine disturbance the follicles, and possible some other parts, were very early so modified that they could not subsequently recover their normal capacities. It is perhaps still more probable that the condition is not of endocrine origin at all, but due to a, possibly new, mutation analogous to the mutations which have produced partially hairless strains of mammals and the Transylvanian naked-necks[5] or 'turkhens" among fowls.

It would be idle to speculate further as to the actual cause of this particular anomaly, but in the light of the behavior of the Leghorn graft, which has remained normal and unaffected throughout, the case suggests caution in attributing such conditions as this to the immediate effect of an endocrine disturbance. If there was any causal endocrine influence at all, which is doubtful, it could have been effective only during an early period of development.

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3 Danforth, C. H. Studies on Hair, VI. Aberrant Forms of Hair Growth. *Archives of Dermatology and Syphilology,* vol. 12, pp. 212-232. 1925.

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5 Greenwood, A. W. The "Hackless" Fowl. *Proc. Roy. Phys. Soc,* vol. 21, pt. 3, pp. 123-129. 1927. (Bibliography of papers by Davenport, Crew, and others.)

Books Received

BOOKS are acknowledged in this column as received, and such acknowledgment must be regarded as sufficient return for the courtesy of the sender. As far as space permits, books that contain material of special interest to the readers of the Journal will be reviewed in later numbers.

Letters from the Steppe: Written in the years 1886-1887 by William Bateson. Edited, with an introduction, by Beatrice Bateson. "These letters, which have much vivacity and vividness, were written by the great biologist when, as a young man, he went on a natural history expedition to the West Central Asian Steppe. He saw the people in their primitive simplicity, a dozen years before the advent of the railway. Innocent of any craving for publicity, his book presents a picture of great animation, to a large extent true to life even today." Pp. 222. London, Methuen & Co., Ltd., 1928.

Elementary Eugenics: A Revision of "The Third and Fourth Generation." By Elliott R. Downing. Pp. 137. 10 Chapters. Price, $1.75. Chicago, The University of Chicago Press, 1928.

Victim and Victor: By John Rathbone Oliver. Pp. 435. 26 Chapters. Price, $2.50. New York, The Macmillan Company, 1928.

PIGMENT INHERITANCE IN THE MEXICAN KILLIFISH

Interaction of Factors in *Platypoecilus maculatus*

MYRON GORDON

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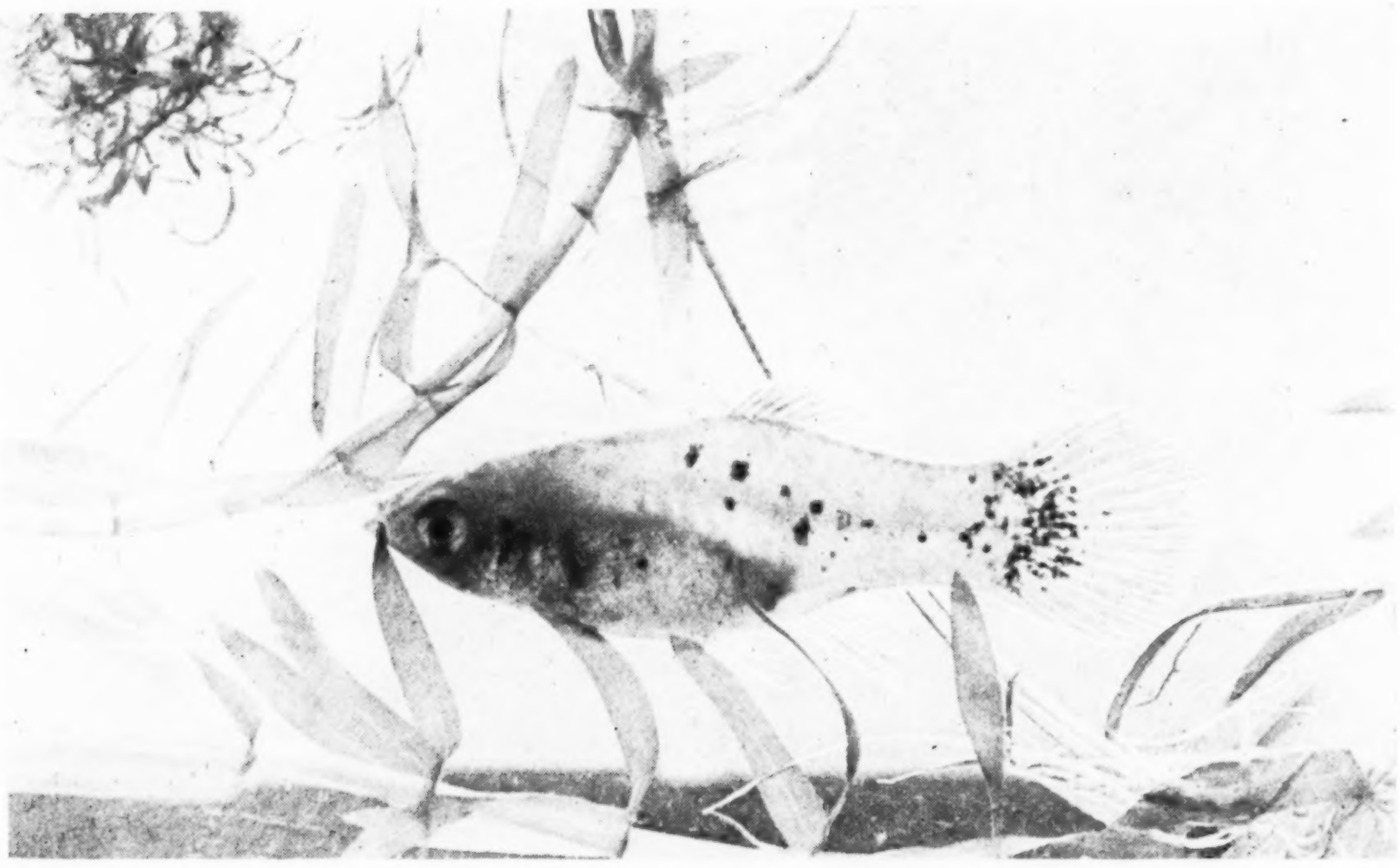


SPOTTED NON-STIPPLED KILLIFISH

Figure 12

Female of *Platypoecilus maculatus*, spotted, non-stippled type, pedigree 40-1, the one used in the test experiment. Note the small number of spots and their restricted location on the caudal peduncle. When crossed with a non-spotted. stippled male, the progeny have these spots extending over the entire body.

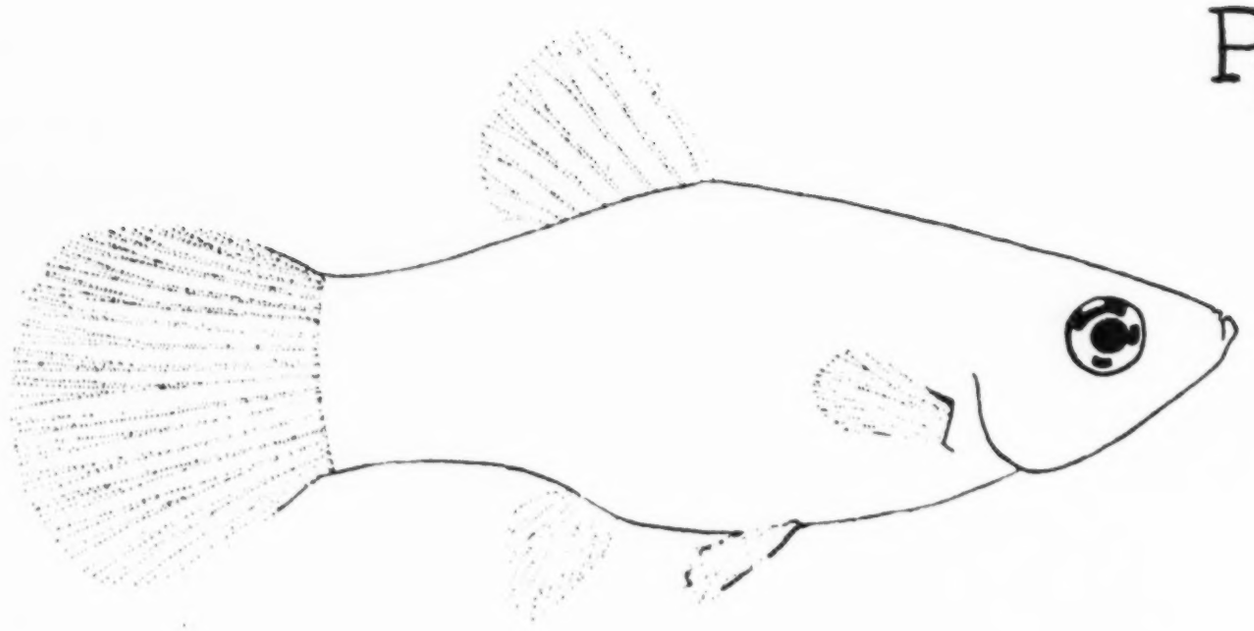
IN a previous paper* the inheritance of two types of melanophores, or black pigment bearing cells, in the small Mexican killifish, *Platypoecilus maculatus*, was discussed. Evidence was presented which indicated that the smaller of the two kinds of melanophores, called micro-melanophores or *stipples* are controlled by a dominant autosomal gene (*St*); and the larger melanophores, called macro-melanophores or *spots* are controlled by a dominant sex-linked gene (*Sp*).

One of the parental types had both factors present: *spots* and *stipples*, while the other was a double recessive being *non-spotted* and *non-stippled*. In the second generation, due to the segregation of the factors for spots and stipples there were four phenotypes. Two of these were new: the *spotted, non-stippled* and the *stippled, non-spotted*.

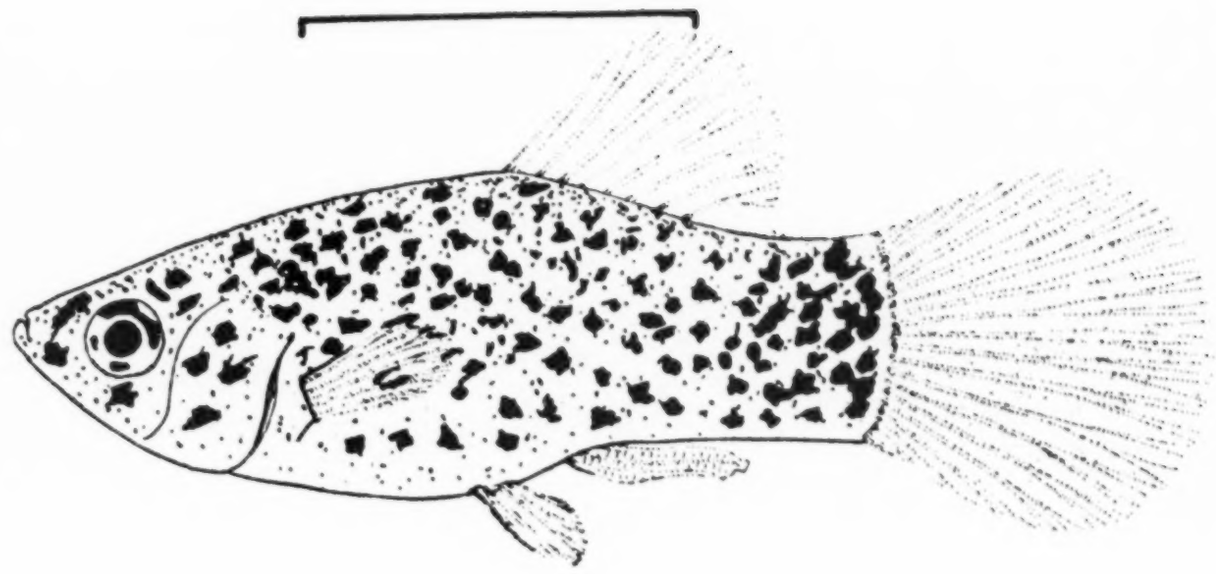
The curious thing observed about these two new F_2 patterns was that first, with respect to the spots: when spots are present alone, as in the spotted, non-stippled animal, there are fewer of them than when they appear simultaneously with stipples (as in the

*GORDON, MYRON. 1927. The genetics of a viviparous top-minnow, Platypoecilus; the inheritance of two kinds of melanophores. *Genetics* 12:253-283.

P_1 Types

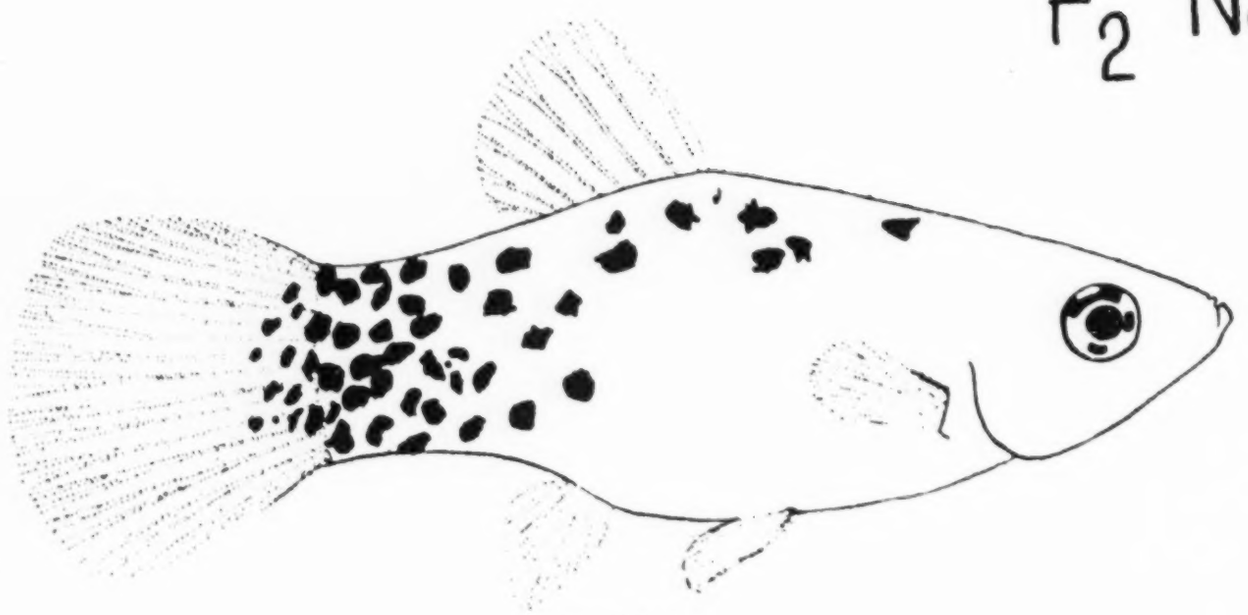


Non-Spotted-Non-Stippled

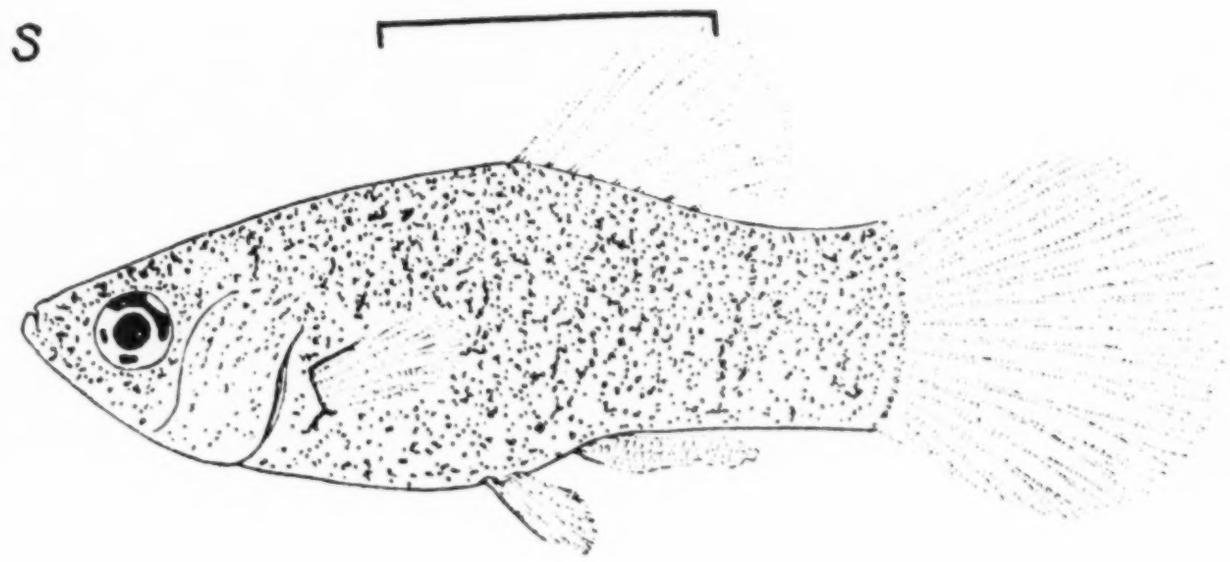


Spotted-Stippled

F_2 New Types



Spotted



Stippled

FOUR MELANIC PATTERNS IN THE KILLIFISH

Figure 13

The upper two figures show parental types. In the F_1 spots and stipples are dominant. In the F_2, two new types appear; these are illustrated below. The parental types reappear also. Females are on the left, males on the right—but the patterns illustrated are not confined to any one sex. It is curious that in the presence of the spotting factor the stippling factor has the effect of extending the spots over the entire surface, while the stipples are actually reduced in number.

PHOTO-MICROGRAPHS OF THE MELANIC PATTERNS

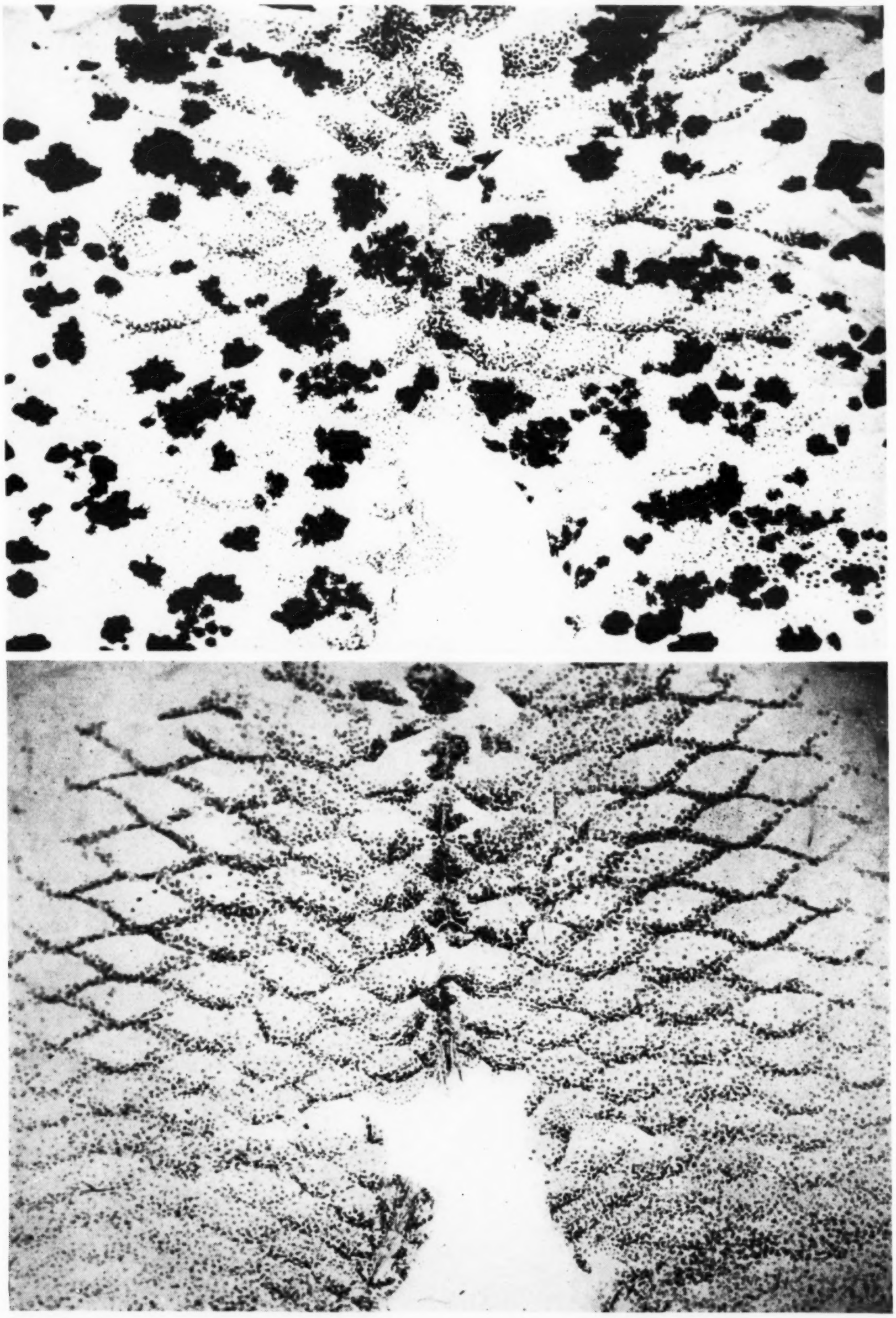
Figure 14

A highly magnified photo showing: St=stipples or micro-melanophores and Sp=spots or macro-melanophores. This photo made from spotted-stippled skin shown in Figure 15.

spotted, stippled type); secondly with respect to the stipples: when stipples are present alone as in the non-spotted, stippled animal, there are more stipples present than when they appear simultaneously with spots (as in the spotted, stippled type).

Further study of these various F_2 patterns with respect to the numbers and distribution of their melanophores has resulted in the establishment of the following facts:

Pattern	Melanophores	
	Micro- (stipples)	Macro- (spots)
Non-spotted, non-stippled	Wanting	Wanting
Non-spotted, stippled	The body is entirely covered by these cells which appear more numerous on the mid dorsal line. On the body sides they outline the scale pockets which presents a net-like effect. In this manner they reach almost to the ventral portion of the body.	Wanting



SPOTTED AND STIPPLED PATTERNS

Figure 15

Above—The major portion of the skin of a spotted, stippled variety. The portion of the skin taken is marked by a bracket in Figure 13. The entire skin is removed from the animal and mounted on a microscopic glass slide and then photographed. The torn space at the bottom centre indicates the position of the dorsal fin which was removed before mounting.

Below—The major portion of the skin of a non-spotted, stippled fish showing the full extent of stippling.

THE SPOTTED PATTERN

Figure 16

The entire skin of a spotted, non-stippled fish. Note how few macro-melanophores are present; there are fewer here than in only a portion of the skin as illustrated in Figure 15. The presence of the Stippling factor has the effect of increasing the distribution of the spots.

Pattern	Melanophores	
	Micro (stipples)	Macro (spots)
Spotted, non-stippled	Wanting	These are confined to the caudal peduncular region generally. Here they are as numerous as in the Spotted, stippled type described immediately below. Cephalad of the caudal peduncular region they are greatly reduced in numbers occurring only in about 20%-40% of the maximum as seen in the Spotted, stippled type. Their distribution cephalad is irregular.
Spotted, stippled.	These are confined mainly to the mid dorsal line from the tip of the snout to the tail, sending bands of these melanophores down the sides, but never completely covering the sides as seen in the non-spotted, stippled type. The head may be completely covered as well as the rays of the fins. In general the lower half of the body is entirely devoid of these cells.	These pigment cells are more or less evenly distributed over the entire body appearing slightly more numerous on the caudal peduncle and on the upper half of the body. In the caudal peduncular region the spots are made up of small groups of macro-melanophores whereas further cephaled the spots are larger being composed of larger numbers of cells to the group.

The above observations would make it appear that while the *Sp* factor has a partial inhibitory effect upon *St*, the *St* factor, on the other hand, enhances the effect of *Sp*. The inhibitory power of *Sp* over *St*, however, is not as great

as the power *St* has in increasing the effect of *Sp;* for while *Sp* may reduce the effectiveness of *St* only about 30 per cent, *St* increases the effectiveness of *Sp* about 70 per cent. This may be summarized in the following table:

Pattern	Number of melanophores expressed	
	Micro- (stipples)	Macro- (spots)
Spotted, stippled	70% or the minimum	100% or the maximum
Spotted, non-stippled	0%	30% or the minimum
Non-spotted, stippled	100% or the maximum	0%
Non-spotted, non-stippled	0%	0%

It seemed that the most effective way to test the inversely reciprocal interaction of *Sp* and *St,* as stated, would be to cross the Spotted, non-stippled type (that one showing the minimum nummer of macro-melanophores) with the Non-spotted, stippled type (the one showing the maximum number of micro-melanophores). If the resulting progeny resemble the typical spotted, stippled type which has the maximum number of macro- and the minimum number of micro-melanophores, the probabilities are that the facts as stated are correct.

With the above purpose in mind, two females of Pedigree 40-1 and 40-2 of the genetic constitution *Spsp stst* were crossed with a male *spsp StSt* of pedigree 60-11. Two classes of progeny resulted under pedigree 101 as follows: 56 Spotted, stippled individuals and 52 Non-spotted, stippled. The former had their usual proportion of macro- and micro-melanophores, exhibiting the maximum number of the second kind. The latter class followed their own particular tendency and exhibited the maximum number of micro-melanophores. Both results are in accordance with the facts as stated above. By inbreeding the above animals (101-1 × 101-11) four phenotypes are again obtained, each of which has the typical proportion of melanophores.

That it is the specific genetic factor *St* and not some other gene which is responsible for the extention of the action of *Sp* may be established by the following observations from other experiments. In *Platypoecilus maculatus* there are among other varieties the following: the Ocellus, the Twin-spot and the Crescent. In all of these the definitive pattern is made up of closely grouped micro-melanophores which, however, are confined to the caudal peduncular region. (It will be recalled that the effect of *St* is to extend the distribution of stipples uniformly over all of the body of the animal). Although combinations of the Spotted, non-stippled type with each of the above mentioned patterns has been made, no extention of the action of *Sp* is detected.

THE INHERITANCE OF LEFT-HANDEDNESS

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NOT a great deal of work has been done in the past that presented definite proof that left-handedness is inherited.

Many papers have been written as to its cause, such as the embryonic formation of the subclavians, the size of the lobes of the cerebrum, the location of the Brochas area in the brain. Others have endeavored to show that it is more prevalent in criminals and imbeciles. The trait has been viewed from many angles, but no worker more recent than Ramaley has tried to show that the trait appeared according to Mendelian law, and even in this the population was very limited. It was this paper of Ramaley's that was responsible for our starting this investigation.

This paper hypothesised left-handedness as a Mendelian recessive, but only showed two families in which both parents were left-handed and in one of these not all the children were left-handed, as would be expected from a Mendelian recessive.

It was our hope in starting this work that we find only families in which both parents were left-handed. To this end we employed the local press and the articles were in turn copied by the national press associations and we received letters from left-handed people all over the country. It appeared that so many people had so many degrees of left-handedness that it was necessary to draw a line as to who was and who was not left-handed. Our criterion was that in order to be classed as left-handed a person must write with his left hand. This appeared to be the best standard because the reflex pathways necessary to writing are extremely complicated and are much more likely to be an inherited structure than the reflexes necessary to handling other simpler implements with the left hand.

The search for families in which both parents are left-handed led us still further, and the 1927 incoming class of Freshmen at Ohio State were all questioned as to their handedness, their parents' and their brothers' and sisters' handedness. From this large amount of data we hoped to show that it was a Mendelian recessive, but a compilation of the data forbids it. In fact, we cannot hope to show in this paper how left-handedness is inherited, but we will present proof that it is inherited.

There are too many variables in a problem of this kind for the human mind to cope with.

There were 2,177 incoming Freshmen assailed with the questions of handedness; these with their parents and brothers and sisters gave us a population of 12,068.

We not only obtained in this survey some interesting figures on left-handedness, but also some interesting facts on the size of families and the number of boys and girls in families sending students to Ohio State.

Of these 2,177 students, 94 were left-handed, or 4.31%. This checks very closely with figures published by Lombroso and Jones and is close to those of Smith. There are others, however, who place the percentage much lower.

These 2,177 students had 4,354 parents divided as follows: 2,113 right-handed mothers and 64 left-handed mothers; 2,086 right-handed fathers and 91 left-handed fathers. This gives us a percentage of 4.13 of the fathers left-handed, while only 2.94% of the mothers were left-handed.

These students had 2,682 sisters, 101 of whom were left-handed, or 3.76%.

They had 2,855 brothers, 173 of whom were left-handed, or 6.05%.

This gives us a total population of 12,068; 523 of these were left-handed, or 4.34%.

The total female population was 4,859; 165 being left-handed, or 3.39%.

The total male population was 7,209; 358 were left-handed, or 4.96%.

It is well to note here that approximately 50% more males were left-handed than females.

In this population there were 9 families in which both parents were left-handed. There were 55 families in which the mother was left-handed and 82 families in which the father was left-handed. In considering these families in which just the mother or father was left-handed we did not consider the families in which both parents were left-handed (see Table I).

In the 55 families in which the mother was left-handed there were 18 left-handed boys and 9 left-handed girls. There were 110 right-handed boys and 59 right-handed girls, giving us a total childship of 196, 27 of whom were left-handed, or 13.77%.

In the 82 families in which the father was left-handed there were 21 left-handed boys and only 5 left-handed girls. There were 151 right-handed boys and 91 right-handed girls, giving us a total childship of 268, 68 of whom were left-handed, or 9.7%.

Besides the 9 families found in this population where both parents were left-handed we were able to secure through our newspaper items 24 additional families in which we established positively that both parents were left-handed (see Table II).

In the 33 families in which both parents were left-handed there were 26 left-handed boys, 20 left-handed girls. There were 37 right-handed boys, 17 right-handed girls, giving us a total childship of 100, 46 of whom were left-handed, or 46%.

It will be remembered that 4.39% of the total population were left-handed. Note then that in the 82 families in which the father was left-handed 9.7% of the children were left-handed, and in the 55 families in which the mother was left-handed 13.77% of the children were left-handed, while in the 33 families in which both parents were left-handed 46% of the children were left-handed.

After deducting from a total population of left-handed children those children whose mothers or fathers or

Table I—Data of Families and Children

	TOTAL	LEFT HANDED BOYS	PER CENT	LEFT HANDED GIRLS	PER CENT	TOTAL LEFT HANDED	PER CENT
FAMILIES FATHER LEFT HANDED	82	21	12.2%	5	5.2%	26	9.7%
FAMILIES MOTHER LEFT HANDED	55	18	14.01	9	13.02%	27	13.77%
FAMILIES BOTH PARENTS LEFT HANDED	33	26	39.6%	20	54%	46	46%
FAMILIES BOTH PARENTS RIGHT HANDED	2031	223	5.1%	84	3.1%	307	3.9%
TOTAL FAMILIES OBSERVED	2177	267	5.3%	101	3.8%	368	4.83%

* This includes 25 families that were secured outside of the census taken of incoming Freshman. These families were not used elsewhere in the data.

Table II—Families with Both Parents Left-Handed

Case No.	Boys Right	Boys Left	Girls Right	Girls Left
233	2		1	
391	2	1		
549	2	3		2
897	1			
998	1		1	
1516	2		1	
1652	1		1	
1703	1			
1766	2			1
2183		3		
2184	1	3		1
2185	1			2
2186	2		2	
2187	2	1		
2188		2		
2189	1			
2190	1		1	
2191	2			
2193		1		
2194		1		
2195		3		5
2196	1			1
2197	3		2	
2199		4		3
2206				1
2209	2	2	2	2
2210				2
2212	1		1	
2213	1			
2215	1	1	2	
2217	1			
2218		1		
2219	3		3	
TOTALS	37	26	17	20

both were left-handed we have only 166 left-handed children whose fathers and mothers were right-handed, or 2.1%.

Whereas 171 families in which one or both of the parents were left-handed produces 98 left-handed offspring, 2,031 families in which the total offspring was 7,714 only 270 were left-handed.

Hence from families in which one or both of the parents are left-handed we get a percentage of 17.34% of the children left-handed, while in families in which neither of the parents are left-handed only 2.1% of the children are left-handed.

If left-handedness is not inherited we would not find over 5% of the children left-handed in any of these families, regardless of the handedness of their parents.

It is very evident that there is some sex influence manifested in the inheritance of left-handedness as shown by the larger number of left-handed boys in this population. It is also apparently transmitted differently where the father is left-handed as note the small number of left-handed girls in these families. There can be no doubt that the trait is inherited, but surely not as a Mendelian recessive.

Siemens presents 21 cases of apparent identical twins in which one was left-handed and the other right-handed, and cites this as evidence that left-handedness is not an hereditary factor. The probable explanation of this is mirror imaging, so often found in identical twins, or it may possibly be the position in utero of the right-handed twin which would prevent it from developing into a left-handed one.

In passing it is interesting to note that of the 2,177 students entering Ohio State and representing as many families that these families had a total of 7,807 children, an average childship of approximately 3.5; but only 2,775 of these children were girls, or practically two boys to every girl in families sending boys to the University.

The writer wishes to acknowledge the splendid help and cooperation of Professor W. M. Barrows in preparing this paper.

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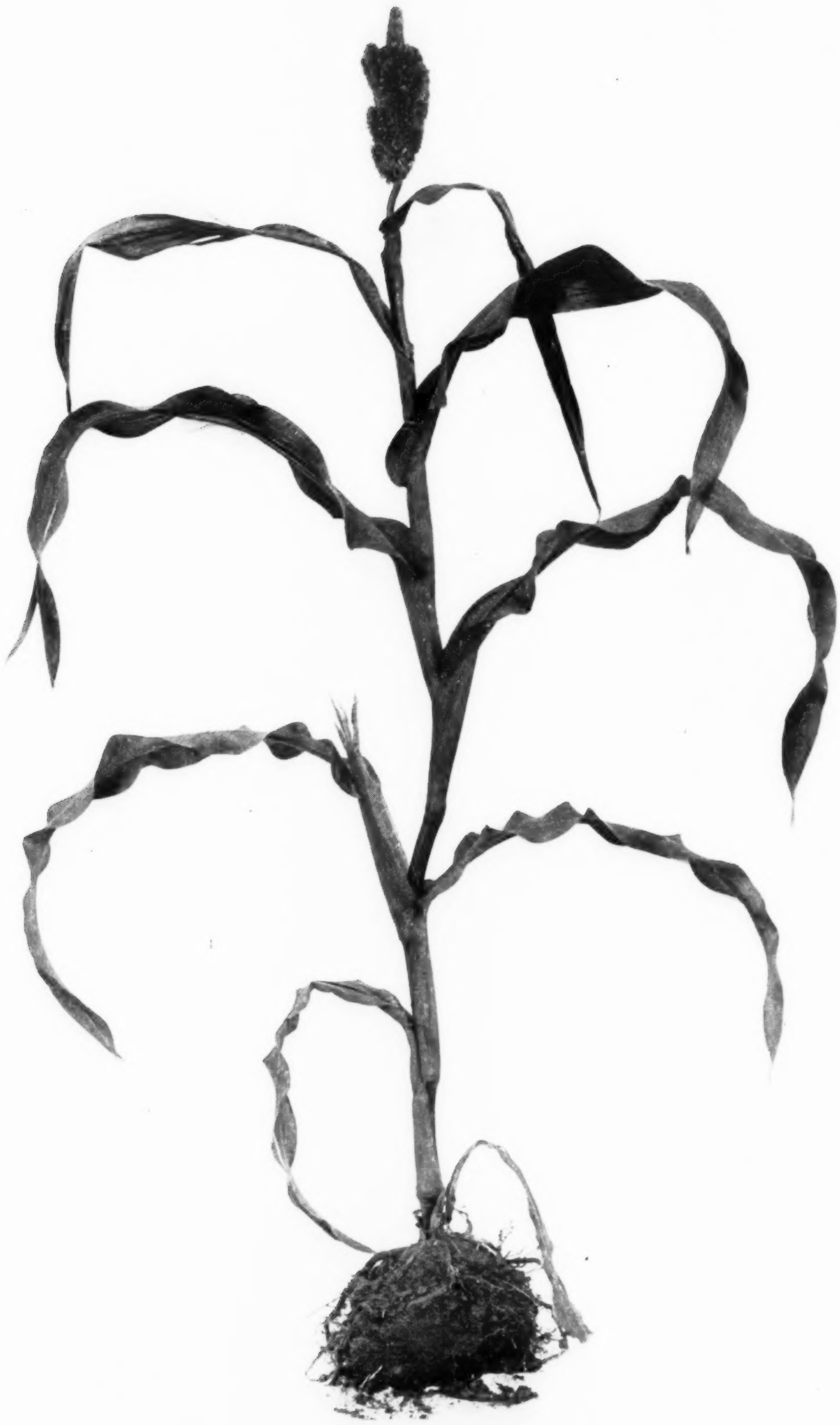

A SORGHUM-TASSEL PLANT

Figure 17

Showing the characteristic appearance of the plant, with its sorghum-like, seed-bearing tassel.

HERITABLE CHARACTERS IN MAIZE

XXXIII Sorghum Tassel*

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SORGHUM tassel appeared in a selfed line of Rustler White Dent corn. This was one of several hundred selfed lines grown as one phase of a problem which had as its purpose the attempt to produce an improved variety for Central Minnesota. This abnormality was named sorghum tassel because of its superficial resemblance to sorghum. The characteristic sorghum-like appearance is apparent in Figure 17, in which is shown a plant of the sorghum tassel strain a few days prior to the silking period. The characteristic branching of the tassel may be seen in a view of the tassel with the branches on one side removed, taken a few days before the period of dehiscence of the anthers (see Figure 19). The tassel bears both staminate and pistillate florets irregularly distributed. Under normal field conditions mature seeds are produced rather commonly in tassels of sorghum tassel plants (see Figure 19). The ears on sorghum tassel are irregular rowed or have a characteristic lack of rows. As a rule, the ears produce a few male florets and masses of proliferated tissue of varying size on or near the tip of the ear. Immature sorghum plants can be differentiated from normal plants, in many cases, by the presence of glumes of male flowers among the female flowers. These may be seen before the silks are fertilized when the pistillate flowers produced on the ear are very immature. The characteristic irregularity of seeds on the ears of sorghum tassel plants may be noted in Figure 18.

Sorghum tassel appeared to be a simple recessive and a relatively easy character to study. From various crosses of normal vs. sorghum tassel plants there were obtained in F_2 8,215 normal tassel plants to 2,765 sorghum tassel plants. The deviation in numbers from a 3:1 ratio was 230 with a P. E. in numbers of 32.0. This deviation is greater than should be expected on the basis of random sampling. Sorghum tassel plants are weaker than normal plants which may explain the deviation.

Like the tassel seed types reported by Emerson,[3] the production of a vigorous ear on sorghum tassel plants is aided by de-tasseling the plant. While endosperm and seedling characters are somewhat easier to study than mature plant characters it appears desirable to learn the linkage relations of as many characters as possible in order to aid in building up a chromosome map for the hereditary characters of maize. Characters related to the expression of sex are of interest, for the genetic complexity of sex in monoecious plants can be appreciated only by studying hereditary deviations from the normal expression of sex and learning the map position of the genetic factors involved. For these reasons, preliminary studies of linkage relations have been made in relation to genetic factors in known linkage groups. These preliminary studies have been made in all cases by the use of the F_2 generation for the characters involved.

Linkage Relations of Sorghum Tassel†

The sorghum tassel strain was crossed with the aleurone testers *Pr*,

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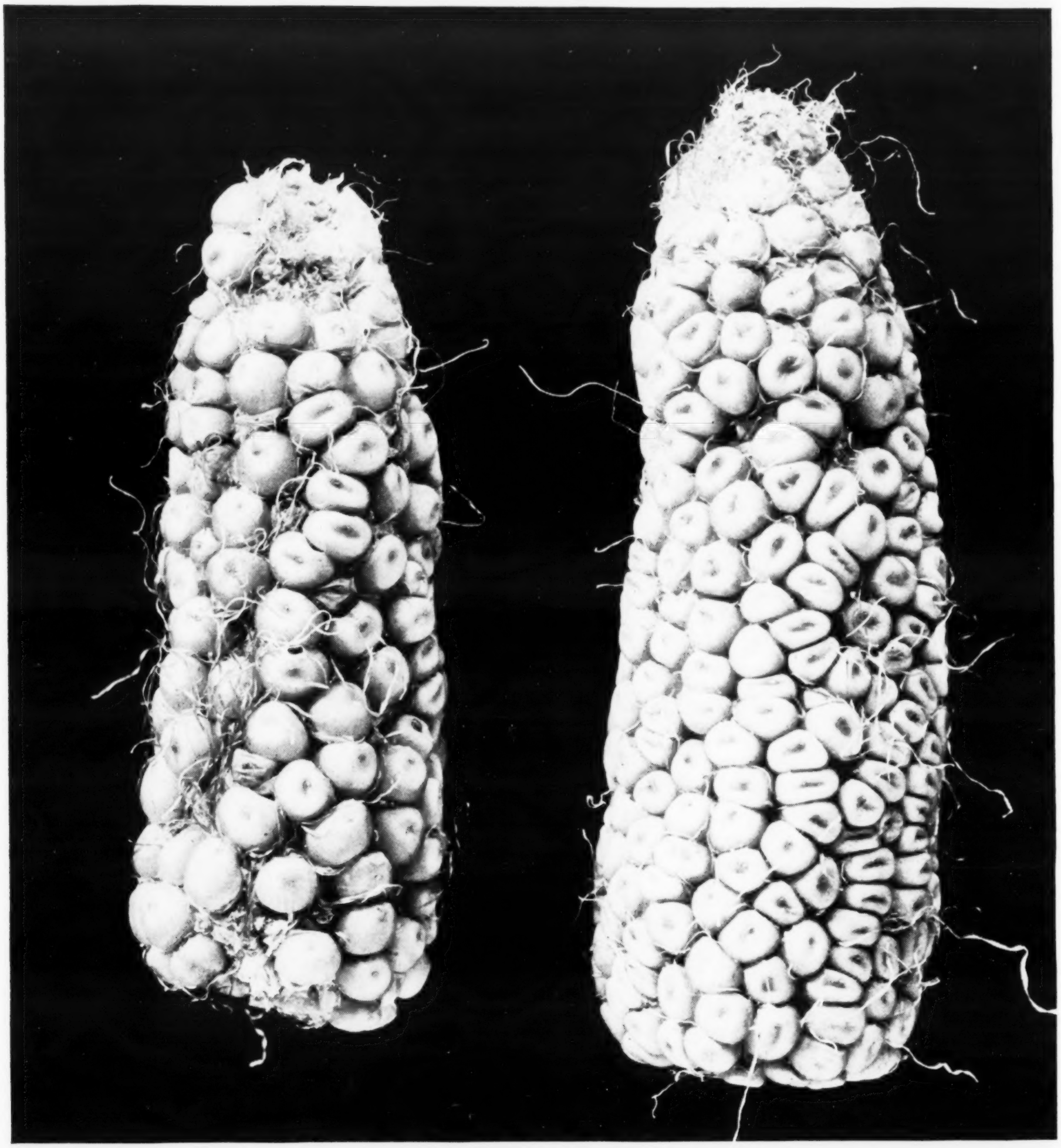
†For a short summary of linkage groups in maize, see Breeding Crop Plants.[4] Pp. 260-264.



SORGHUM-TASSEL EARS LACK REGULAR ROWS

Figure 18

Ears of sorghum-tassel plants are irregularly rowed or entirely lack rows. A few male florets and masses of prolifesating tissue are often produced on or near the tips of the ears.

C, *R* and *A*. In crosses with the *Pr* and *A* aleurone testers purple seeds were obtained, while crosses with the *C* and *R* testers produced colorless aleurone. This led to the conclusion that the strain of sorghum tassel used was genotypically *AA cc rr PrPr* for aleurone color.

Linkage studies were made in which segregation for the sorghum tassel factor pair *Sg sg* was studied in relation to the following well-known factors in the eight recognized linkage groups: *C c*, *Sh sh* and *Wx wx* factor pairs in the "C" group; *R r* and *G g* factor pairs in the "R" group; *Su su* and *Tu tu* factor pairs of the "su" group; Ts_1 ts_1 and *Lg lg* factor pairs in

TASSELS BEARING SEEDS

Figure 19

At Left—A tassel of a sorghum-tassel plant with some of the branches removed. The silks indicate the presence of pistillate flowers, which are irregularly distributed through the tassel. Taken a few days before the dehiscence of the anthers.

At Right—Mature tassel of this strain showing seeds in the tassel.

the "B" group; *Y y* factor pair in the "Y" group; *Br br* and *P p* factor pairs in the "P" group; *A a* factor pair in the "A" group; and Gl_1 gl_1, *Bn bn* and *Ra ra* factor pairs in the "Bn" group. The *Pr pr* and *flinty-floury* factor pairs whose definite linkage relations have not been demonstrated were studied in relation to sorghum tassel. All studies were made with F_2 data. The methods of calculating cross-over percentages are given as footnotes in Table I.

No close linkage relations were obtanied in any of the above crosses. The detailed data and crossing-over values are given in Table I.

In the cross of sorghum tassel with ts_1, the first generation plants were normal and in F_2 there was a ratio of 627 normal, 159 sorghum tassel, 199 ts_1, and 6 doubtful plants. The results were compared with the calculated on the basis of a 9:3:4 ratio. A X^2 value of 22.3 was obtained. The deviation from a 9:3:4 ratio is very large in this case. Besides the 985 plants which were classified there were 6 plants which were abnormal in tassel type but were like neither sorghum tassel nor ts_1. On the basis that sorghum tassel and tassel seed are each dependent upon a homozygous recessive factor the results obtained cannot be explained on a linkage basis unless the crossing over percentage is greater than 50.

The study of a linkage relation with flinty-floury and *Sgsg* was obtained from a cross of sorghum tassel flinty with *R* tester floury. The seeds produced on ears of F_1 plants segregated in a 1:1 ratio for the flinty-floury character. The study of linkage relations was made by the use of Collins' formula where

$$p = \frac{2(Ab + aB)}{n} - .5$$

and *Ab* and *aB* contain the new combinations of parental characters. A calculated value of p of .5682 was obtained. Collins and Owen have suggested the use of X^2 as a test of independent Mendelian inheritance by the comparison of the observed ratio with a theoretical ratio for independent inheritance. The theoretical ratio is calculated on the basis of the observed segregation for the separate character pairs. The method appears desirable in many cases where deviations from the expected Mendelian ratio cannot be explained by errors of random sampling. A calculated X^2 of 3.20 with a P value of .0715 was obtained. The results indicate independent inheritance of the factor pairs concerned.

Abnormal Types in Crosses of Sorghum Tassel With Tunicate

Heterozygous tunicate plants, *Tutu* were crossed with sorghum tassel. The F_1 consisted of heterozygous tunicate and normal tassel plants. The F_2 progeny of F_1 heterozygous tunicate plants produced all combinations of the factor pairs *Tutu* and *Sgsg*. There were 22 normal tassel plants, 553 tunicate heterozygous and homozygous plants which gave no evidence of the sorghum tassel character, 136 heterozygous tunicate plants with ear and tassel characters which were somewhat characteristic of sorghum tassel plants, 68 sorghum tassel plants with no evidence of the tunicate character, and 46 plants which produced a spongy or cauliflower type of lateral and terminal inflorescences (see Figure 20).

The 136 heterozygous tunicate plants which were presumably homozygous for the sorghum tassel factor *Sgsg*, produced lateral inflorescences which contained some proliferated tissue. The ears of these plants showed a tendency to become branched and the proliferated tissue of the lateral inflorescences resembled the cauliflower type of ear described recently by Collins[2] for the homozygous condition for the tunicate and ramose characters. The amount of such proliferation was not very great. The 46

CAULIFLOWER INFLORESCENCES

Figure 20

In the second generation of a cross between sorghum-tassel and tunicate, the segregates homozygous for both tunicate (TuTu) and sorghum-tassel (sg sg) produced inflorescences of a cauliflower type. Since no seed is produced a cauliflower strain of maize cannot be perpetuated. A lateral inflorescence (cob) is shown at left; a terminal inflorescence (silk) at right.

TABLE I—Study of Linkage Relations of the factor pair for Sorghum Tassel, Sg sg and factor pairs in known linkage groups F_2 ua.a.

Culture	Character	Zygotic Classes				P
		AB	Ab	aB	ab	
H 140	Cc & Rr	541	170	491	156	.5506 [á]
H 169	"	339	92	318	97	.5444
H 139	A a	544	173	712	216	.5038 [a]
H 139	Pr pr	591	183	183	63	.5144 [b]
H 140	Pr pr	413	134	128	36	.4796
H 140	Wx wx	809	261	223	65	.4855
H 169	Sh sh	549	162	108	27	.4761
H 170	G g	749	234	181	53	.4906
H 167 obtained	Su su	665	113	225	25	
H 167 corrected	"	665	255	225	56	.4392 [c]
H 167	Tu tu	669	212	251	69	.5201 [c]
H 139	Lg lg	50	22	22	8	
H 171	"	873	264	289	76	
Total	"	923	286	311	84	.4806
H 171	"Y"	863	299	270	70	.4591
H 140	"Y" in Ramose	820	262	245	82	.5065
H 141	P p	308	110	124	38	.5241
H 165	Br br	267	76	82	32	.5439
H 139	Bn bn	517	151	195	65	.4814
H 166	"	772	220	306	67	.5373
H 166	Gl_1 gl_1	784	210	294	77	.4955
H 168	Ra ra	816	266	239	88	.5170
H 170	Flinty Floury	526	110	457	124	.5682 [d]

[á]The value of p or crossing over expressed as a decimal fraction was calculated for the coupling phase from a formula given by Collins[1] for the linkage relations determined from a 9:7 and 3:1 ratio where $(1-p)^2=\frac{16(AB+ab)-7n}{6n}$, and (AB+ab) contain the new combinations of characters.

[a]Calculated from the formula for repulsion, $P^2=\frac{64(AB+ab)-25n}{18n}$ used by Owen[5] with special reference to the Aa aleurone factor pair.

[b]This and all subsequent values of p are calculated by the use of Yule's coefficient of Association, except where noted.

[c]The starchy seeds when planted produced about 70 per cent mature plants while the sugary seeds matured only 31 per cent. In order to make the results more comparable the progeny of the sugary seeds were placed on a 70 per cent germination basis. As the germination percentage was low it is doubtful if the apparent slight linkage is of any significance. The linkage of *Sgsg* with *Tutu* were obtained from the same cross, consequently the same correction was made.

[d]Calculated from Collins formula $p=\frac{2(Ab+aB)}{n}-5$, and Ab and aB contain the new combination of parental characters.

plants which were of the cauliflower type were somewhat reduced in size and both lateral and terminal inflorescences were of the cauliflower type. They are assumed to be homozygous *TuTu sgsg*. Among the proliferated tissue occasional silks were produced in both terminal and lateral inflorescences.

The close resemblance of the homozygous *TuTu sgsg* plants to those obtained by Collins for the homozygous condition of tunicate and ramose is of interest. The results furnish another example of the combination of two mutative conditions *TuTu* and *sgsg* which together produce a very striking abnormality.

Discussion

The difficulties of studying linkage relations with F_2 data alone are very evident from these experiments. Recessive mutations are frequently less vigorous than normal characters and the combination of the double recessive condition may lead to a further reduction in vigor and a greater elimination of individuals of the double recessive class. In material of this nature the use of the coupling phase is desirable. In many cases the making of the cross in the coupling phase, where recessive characters are concerned, would delay the study for several years. By studying the data carefully, without relying entirely on calculated cross-over values, it is possible to obtain a good indication of any possible close linkage relation. Apparent loose linkage relations must be studied in back crosses before definite conclusions regarding linkage relations are possible.

Summary

1. A recessive variation, called sorghum tassel, *sgsg*, which appeared in a selfed line of Rustler White Dent, is described. It resembles sorghum in the appearance of the tassel which contains both male and female florets. The ear has a characteristic irregularity of rows.

2. Sorghum tassel plants grow somewhat less vigorously than normal plants. From various crosses a total of 11,980 F_2 plants was obtained. The percentage of sorghum tassel plants was 23.08 which is a significant deviation from 25, the percentage expected for a recessive character.

3. The linkage relation for sorghum tassel and eighteen other characters in known linkage groups were studied in F_2. No definite indications of linkage were obtained.

In a cross between sorghum tassel and tunicate, ears of "cauliflower" type were obtained in F_2, these plants being homozygous for *Tu* and *sg*. The plants homozygous for *sg* and heterozygous for *Tu* also gave some evidence of "cauliflower" tissue in the ears of some of the plants.

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